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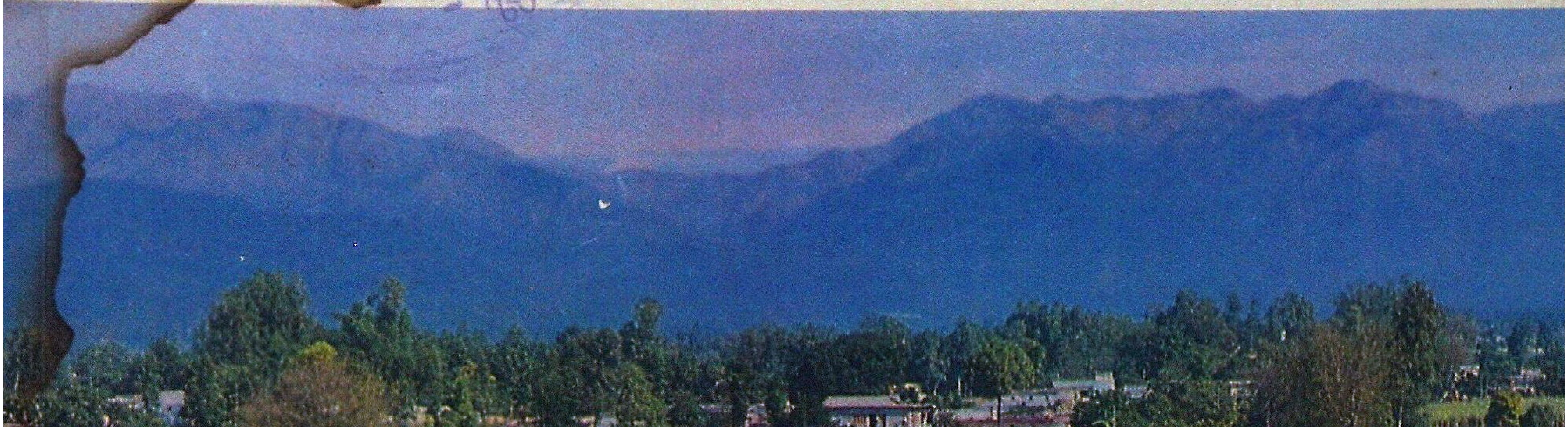

Agroforestry

VOL. 122 JULY 1996 NO. 7

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Agroforestry

FRONT COVER

AGROFORESTRY IN DOON VALLEY, DEHRA DUN.

Photo - Tilak Raj

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AGROFORESTRY MODELS IN INDIA - FOCUS ON DESIGN

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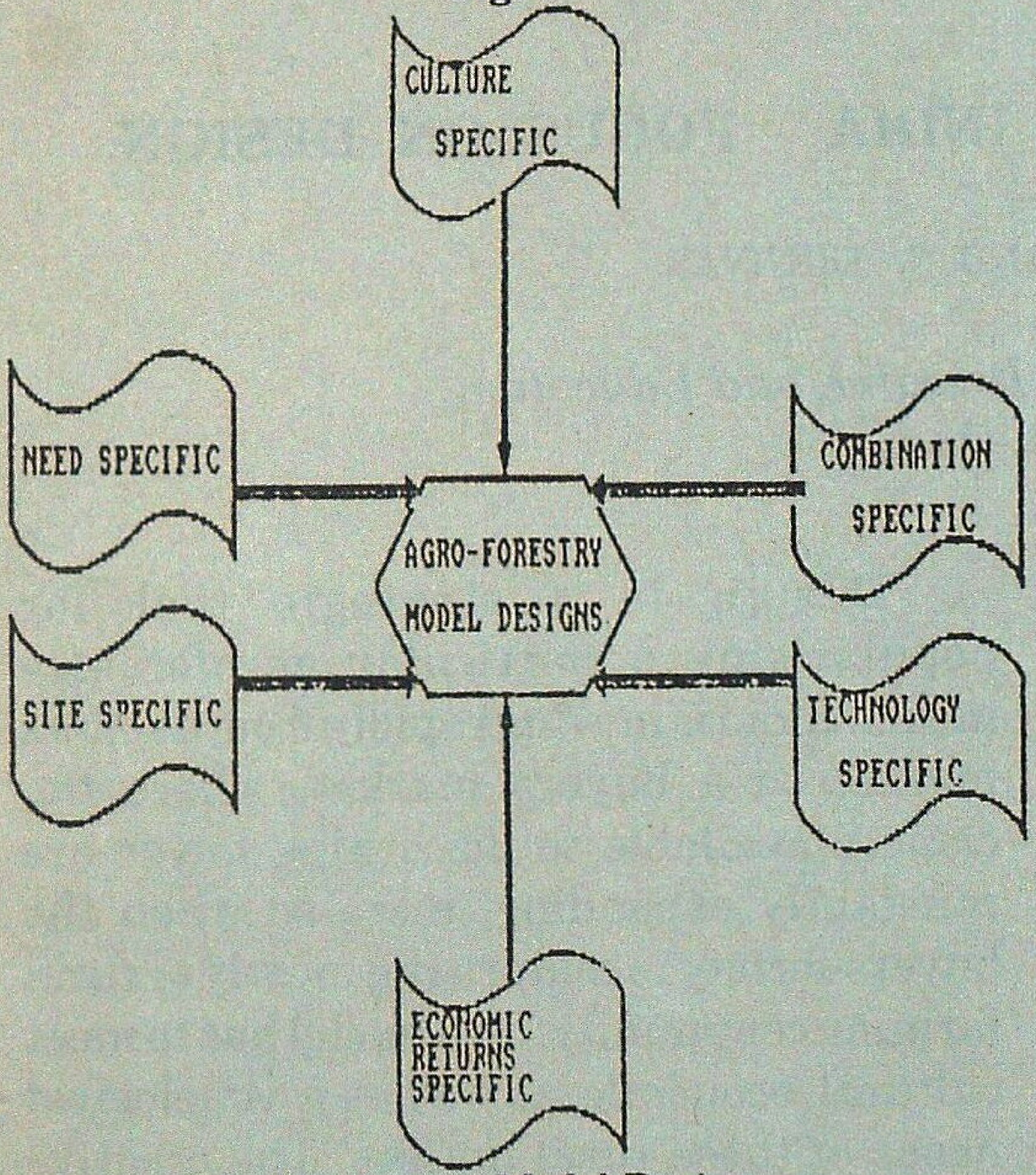
Introduction

The major objective of agroforestry is to optimise production and economic returns per unit area, while respecting the principle of sustainable development. In order to attain this objective, certain agroforestry models have been evolved and standardised, combining optimum landuse system with tree-agriculture-livestock production system to give maximum economic returns, simultaneously or sequentially. However, the models have to be designed in such a manner so as to make them technologically feasible, ecologically sustainable, economically viable, and socially acceptable. Conforming to the cultural ethos of the people few existing models in the country, which are commonly observed in certain areas, are being mentioned below :

Acacia spp. *Butea monosperma* and Paddy Model - Chattisgarh, M.P.
Populus spp. and *Citrus* spp. (Kinnow) and *Glycine max, Plantago ovata* - Tarai belt of U.P.
Populus spp. and *Sugarcane* - Tarai belt of U.P.
Eucalyptus spp. and Wheat - Punjab and Haryana
Albizia spp. and Coffee - Tripura
Tectona grandis and Coffee + Cardamom - Kodagu, Karnataka
Prosopis cineraria & Mustard/*Phaseolus aureus* - Haryana
Tecomella undulata with *Phaseolus aureus*/ Groundnut - Rajasthan
Bahuinia spp. + *Grewia optiva* + regional agricultural crops - Hill Terraces of U.P.
A. indica + *Gliricidia macualata* - South India
Casuarina spp./*Avecenia* spp., Groundnut and Vegetables - Coastal belts

Design is a strategic tool for popularising a particular agroforestry model. India is moving rapidly from a sellers market to a buyers market, where the choices available to discerning buyer are constantly expanding, more so when the buyers society is comprising mostly of rural farming community. So a model has to meet cultural, economic, as well as psychological needs of these rural masses. The creative potential of scientists shall concentrate upon the value engineering, methods of design optimisation, ergonomic considerations, synergic combinations of tree-crop interactions, designs innovation, and development of models, based upon needs, site capacity, economic returns, and above all, the environmental services. The model designs and preferences may be need (Product) specific, economic value specific,

Fig. 1



Agrotoretry Model Design

site specific, cultural value specific, technology specific and combination specific. These design specificities accommodate the main criteria of agroforestry systems i.e. productivity, sustainability and adoptability (Raintree, 1984).

Culture Specificity

The value of an agroforestry model perceived by a villager depends on his cultural beliefs, values, faith into delivery systems, and their past experience with the existing practices. Certain values associated with design are listed below.

(a) *Functional Value* : It consist of instrumental utility of a model in satisfying the basic needs of the rural masses. The models aiming at fuelwood, fodder, grass, timber and non-timber product requirement have functional value.

(b) *Convenience Value* : The easy availability of input resources such as quality planting material, seeds, fertilisers, market infrastructure, irrigation, financial credit, therefore needing minimum effort and time on the part of villager in adopting a particular model.

(c) *Futuristic Value* : The anticipated tangible calculations that the crop-tree yield shall contribute to value in future. The models ensuring conformity with future industrial needs and high returns on investment have futuristic value.

(d) *Social Value* : Value of a model exists because of its social acceptance. The plantations of coconut in combination with pisciculture have social relevance in eastern part of India.

(e) *Status Value* : The value which satisfied the needs of the adapters to maintain or demonstrate their social status or value attached to timber, medicinal and other material value.

The model may not be perceived as having all the values important to the villager. Depending on the needs and the options available in the market, the villager may decide to adopt a particular model. The innovative design is the result of creative transformation emerging from advanced technology combined with empirical methods of peasants (Friere, 1973). The design innovation, a kind of social provenance research seeks social, cultural and economic patterns and conditions that affect people's choices and use of species and specific socio-environmental regimes (Chambers *et al.*, 1989).

Need Specificity

In the village the needs of various

groups of people differ. The needs of land owner, cattle owner and daily wage earner, a local artisan, and landless have different emphasis. The demographic features, family size, male/female ratio, occupation structure, literacy profiles, paying capacity, etc. do affect the needs of villager. Natural resource endowment in nearby areas or scarcity also affects the desire of people storing/producing fuelwood, food, fodder, timber or non-wood forest products. It becomes necessary to incorporate the variables associated with village lifestyle into planning process so that model with best output - need fit may be evolved. Choices for tree species remain in favour of species as *Cocos nucifera, Mangifera indica, Areca catechu, Artocarpus heterophyllus, Tamarindus indica, Anacardium occidentale, Tectona grandis* or *Azadirachta indica.* If need be the wind break the models accommodating *Casuarina equisetifolia. Avecenia officinalis, Syzygium cuminii,* are required. If need be the nutritional fodder the choices for tree species are different. The changes in consumption behaviour patterns of rural as well as urban masses with growing consumerism and consciousness have brought in perceptible changes in need profiles.

Site Specificity

India is divided into nine agro-ecological zones with differing range of productivity. The forest productivity varies from 1.8 m^3/ha to 10.62 m^3/ha per Patterson formula. Landuse alteration is based on land's productive potential. Many agro-ecologists regard these agro-ecosystems as unique settings to evaluate the properties of stability and sustainability. It is, with many advantages, important to understand these systems, primarily because the knowledge of traditional cropping patterns and management practices along with the ecological rationable behind these are being slowly eroded due to fast technological advances. Therefore, understanding the great features of traditional agriculture and forestry, such as ability to bear risk, and the production efficiencies of symbiotic components vis-a-vis soils, etc., can provide vital knowledge, that can be utilized for developing most suitable site specific agroforestry strategies.

The different species of trees and agricultural crops to be considered for various combinations have to be adaptive to the climate and the soil types. The humid Western Himalayan region consisting of hills of Jammu & Kashmir, Himachal Pradesh and Uttar Pradesh does well with *Bahunia* spp., *Cedrus deodara, Eucalyptus* spp., *Grewia optiva,* and *Populus* spp., in combination with *Oryza sativa* (paddy), *Triticum aestivum* (wheat). *Citrus* spp. (Kinnow), *Plantago ovata* (isabgol), crop species, which are suitable for this climate and soil type (Tarai soils). Similarly, the *Artocarpus heterophyllus* + paddy; *A. heterophyllus* + *Corchorus* spp. (jute); *Albizia* spp. + *Coffea arabica* (coffee) combinations are suitable for Bengal-Assam basin and North-eastern parts of the country, having riverine alluvium, taria, lateritic, and red-loamy and sandy soil types. *Acacia, Albizia, Leucaena, Dalbergia* and *Eucalyptus* species along with paddy, pulse crops, oil seed crops forms a viable combination in the drier arid to semi-arid areas with medium to light soils. *Anacardium occidentale* (cashew), *Cocos nucifera* (coconut), *Areca catechu* (arecanut), *A. heterophyllus, Tectona grandis, Grevillea robusta* with paddy, coffee, cardamom, banana, root crops, vegetables have been quite productive combinations under southern coastal eco-climatic sites having lateritic to loamy-sand soils,. Thus conforming to different site conditions and sustainable landuse, suitable agroforestry models may be evolved. The system design shall control soil erosion, maintain soil organic matter and physical properties and promote efficient nutrient cycling (Young, 1989). An input-output computer model depicting changes in soil erosion, soil organic matter and nutrients under Agroforestry Systems with certain simulations may be used as an aid to the design of site specific model. The site amendments based on nutritional deficiencies, soil conservation requirements and erosion proneness may be incorporated while designing the model.

The varied ecozones and heterogeneity is caused due to interaction of varied factors, i.e. elevation, altitude, edaphic conditions, precipitation, wind, steepness, relief and terrain and mountain specificities (Jodha, 1993). The suitable models have to take into account the land capability class and land stability zone in fragile ecosystems.

Combination Specific Design

Demonstration plots, their periodic reports may help in evolving the most suitable design based on combinations. The combinations may be based on spatial as well as temporal designs. The spatial designs accommodate multiple layered vegetation which take into consideration the appearance, the structure, the number of plants and canopy architecture. The temporal design, facilitate combination of vegetation with different biological cycles ensuring sustained yields from the productive system. The climatic conditions like light interception, in other words, the availability of PAR (Photosynthetically Active Radiation) to the under growing crops plays a vital role in the productivity of the entire agroforestry. model. Hence the designing should be considered for these aspects. Similarly, the slope aspect of the hilly terraces, needs a suitable agroforestry design, incorporating specific type of architectural features of different species. In the Southern Kodagu District of Karnataka, the coffee bowl of the country, the west-ward slope aspect of the hills may be suggested for growing higher trees, with coffee plantation. While on the east-ward slopes, the dense canopy tree species needs to be grown, (obviously) for providing good shade since coffee cannot bear direct sun. On the other hand, such a canopy structure may not be proper for the growth of other light loving crops, and susceptible to excessive shading, such as *Lycopersicum esculentum* (tomato), *Solanum melongena* (brinjal), *Daucus carota* (carrot), etc. Thus design specificity of different components in specific combinations may be defined on the basis of potential and requirement of the component species, as in :

(1) Agri-silvicultural Design
(2) Agri-silvi-pastoral Design
(3) Silvi-pastoral Design
(4) Silvi-olericultural Design
(5) Silvi-horticultural (pomocultural) Design
(6) Silvi-flori-apicultural Design
(7) Silvi-aquacultural Design
(8) Silvi-lac/sericultural Design
(9) Silvi-animal husbandry Design
(10) Silvi-medicinal Design (Silvi-Medico Practice)

Thus, the design calls for innovative trails based on resources available, suitable species, edaphic and climatic conditions and supportive infrastructure present. Certain models have been standardised on specific combinations such as Multi-Purpose Tree Species (MPTS) + Vegetables. Under this combination of *Gmelina arborea. Dalbergia sissoo, Acacia* spp., *Albizia* spp. and *Tectona grandis* were tried with summer vegetables like tomato, brinjal, *Hibiscus esculentus* (lady's finger), winter vegetables like *Raphanus sativus* (raddish), carrot, *Spinacia oleracea* (spinach) and rainy season vegetables as *Phaseolus* spp. (beans). *Vigna sinensis* (cow pea) and tomato. MPTS of *D. sissoo. Sesbania sesban* were found to grow well with *Panicum maximum. P. pedicullatum* and medicinal plants like *Withania somnifera, Chlorophytum arundinaceam* along with perenial *Cajanus cajan* (pigeon pea).

While designing the model positive as well as negative allelopathic effects in tree-crop interactions, suplementarity, complementarity and competitiveness amongst different components of combinations shall be taken into account. The effect of plant population density on crop performance shall be taken into consideration. The crops that suffers least from competitive interference or shading beneath trees will be those that yield vegetative parts (Huxley, 1983). The innovative combinations shall accommodate these significant issues.

Technology Specificity

In an deliberated efforts to make the farming enterprise, an economically viable and environmentally sound proposition, increasing cropping intensity both in space and time dimensions and adoption of multiple cropping are being resorted to. The polyculture in intercropping reduces crop pests and diseases as against monoculture with marginal genetic base. Benefits associated with thorough design are better utilisation of component resources, along with soil moisture, nutrients, space both in rhizosphere and atmosphere, higher and stable returns, and therefore, reduced risks of failure, resistance to insects, pests, diseases and weeds.

Coppicing behaviour and nutrient recycling have been studied in detail. The shade effect and allelopathic effects apart from root interactions are to be studied for effective crown architecture. The rates of decay of leaf litter and nutrient release are to be synchronised with the rate and time of absorption of nutrients. The trees with faster rate of litter decomposition and nutrient release shall be preferred. Tree root systems along with their associated Mycorrhizae make efficient use of soil nutrients. Fifty-five tree and shrub species belonging to 32 genera are identified which have potential to maintain soil fertility (Young, 1989). Multistoryed intercropping [*Cocos nucifera* (coconut) + *Piper nigrum* (black pepper) + *Theobroma cacao* (cocoa) + *Ananas sativa* (pineapple)], multilayered canopy architectures are being standardised.

In alley cropping, the food crops, vegetables, etc. are grown in between the hedgerows of woody perennials. These hedgerows are pruned in order to reduce competitive interference while allowing nutrient addition and moisture conservation (Mulching), and allowed to grow when there are no standing associated crops. Prunning alters tree shape, total dry matter production per tree, dry matter distribution within the tree (Huxley, 1983). The pruning practices for branches, roots and main stem facilitate the manipulation of height, branchiness, dry matter distribution, shade, flower bud production and access to immobile soil nutrients (Tejwani, 1979). The suitability criterion for trees/shrubs in alley cropping is to be standardised. Nitrogen Fixing Tree Species (NFTS) and Multipurpose Tree

Species (MPTS) provide in alley cropping system, useful by-products. The ease of establishment, good coppicing ability, profuse regeneration after pruning, rapid growth, etc., are few features, which are to be looked for suitability of tree species and accordingly the technology needs to be evolved. The perturbation are to be constantly monitored for deciphering the limiting factors as well as catalytic factors. Coppicing/pollarding shall be phased to coincide with interplanting of field crops.

While the technologies are defined with reference to the need specific objective, the implied aspects for the aesthetic and the eco-friendly objectives/principles for evolving the tree-crop combinations needs equal emphasis. The prime objective behind bringing forests into the farmers land being environmentally sound ecosystem, that should meet the requirements of the ever loosing forest resource. In other words, the essence in providing such an agroforestry model design requires the technology governing the principles of aesthetic landscaping as also to provide a means for developing the biodiversity of the region/area. This also emphasises for incorporating the indigenous/domestically available phyto-genetic resources as a technology specific ingredient. The provenance research for high yields, disease and pest resistance and stress resilience of MPTS shall support the model design in terms of planting stock availability.

The competitive stress can be exploited to maximise yield per unit area of ground. In practice farmer prefers to maximise yield by avoiding competitive stress rather than by exploiting it. The need is to alter relationship between crops in the horizontal/vertical/temporal dimensions so that the different crops share environmental resources in a way that minimises mutual interference and maximises resource sharing (Bunting, 1976). Spatial dispersal of different crops, crops that grow tallest in turns, phasing the growth cycles of different crops, selection of suitable cultivates, cultural operations pose challenge to the ergonomic creativity of agronomist.

The yield predictions under interactive regimes are to be standardised. Yield modifiers are to be identified with each model so that yield improvement plans may be prepared and related activities be taken. The technological innovations and field experimentations have mutually reinforcing relationship (Raintree, 1984). The continuous improvement in model's capacity shall be aimed at through technological interventions.

Economic Returns Specific Design

The economic return is the biggest motivating force in shaping the preference. There exists a definite shift in planting, harvesting practices in favour of commercial returns. In a survey five most preferred species quoted by the people are *Tectona grandis, Mangifera indica. Eucalyptus* spp., *Cocos nucifera* and *Azadirachta indica* (Rai and Shivshankar, 1993). Similarly the choice of species has also narrowed down due to preference on the basis of economic returns. The flow of income is to be determined and innovative combinations may be tried depending on market availability for giving highest economic returns at frequent intervals. Designs are to be evolved after considering the cost of inputs so as to make system not only economically viable but also sustainable.

As is indicative by the people's preferential attitude towards switching on from *Eucalyptus*, once highly remunerative, to poplar growing in the Western U.P. due to its high assured income by certain industrial units. Similarly, large scale *Leucaena leucocephala* (subabul) is being now replaced in favour of *Tectona grandis* and *Grevillea robusta* in Central parts of India, which favours the economic consideration for evolving an agroforestry model in order to provide quickest optimum economic output.

As also defined, the agroforestry as a Landuse Technology and a Harbinger of transformal changes in rural economy, the very economic criterion should take into consideration for the potential to generate employment, activate entrepreneurial activities by safeguarding the system's sustainability (Mercer, 1985). Optimal use of natural resources, viz; soil, forests, tree, moisture/precipitation, human resources envisages for efficient use of these resources and distribution of the resources objectively.

Thus, providing an access to distribution strategies, policies, technologies and other social considerations. These will ultimately prevail upon the input-output decisions, input-output decisions, maximum net returns, both in terms of revenues and in terms of environmental benefits. The computer software as SARA (Davis, 1989) attempts to quantify, analyse and evaluate the dynamic nature of designs through sensitivity analysis and helps in providing strategic and operational decision support. The multi-period production possibility frontiers are to be evolved. It depends on factors like length of time, rotation age, discount rate, security of land tenure and property rights. The institutional support for making credit and market infrastructure available to rural masses is necessary.

Futuristic Considerations : Considering the technological advances and the cultural changes on which the economic priorities are dependent, the futuristic approach needs to be considered for evolving any agroforestry models, vis-a-vis, design aspects to be incorporated. The role of *Eucalyptus* is being encroached upon by the poplars, and now the trend is switching on to large scale *Tectona grandis* and *Grevillea robusta* growing on the farms. Observing such a phenomenon, we can easily predict the agroforestry models involving *Paulonia* spp. and *Azadirachta indica* plantations, by the thrust and importance being given globally for these species. Thus the system designing should provide/prepare for such prioritisation for tree species, particularly in respect of associated components, viz., crops, livestock rearing, aquaculture and sericulture and methodologies to attain the transformation of rural economies. People's participation is the crux of any agroforestry venture where people decide, mobilise resources, control and share the benefits. The agroforestry models provide an opportunity for integrating short term economic gains and long term ecological sustainability. Such models have wide acceptance in participatory forest management programmes. Further the regional planning exercise in India for agroforestry shall take into account these specificities while designing the Ecological zone compatible models. The challenge lies in transforming the socio-cultural inputs into socio-economic outputs while designing the agroforestry models.

SUMMARY

Design is a strategic tool for popularising a particular agroforestry model. The creative potential of scientists shall concentrate upon the value engineering, methods of design optimisation, ergonomic considerations, synergic combinations of tree-crop interactions, designs innovation, and development of models, based upon needs, site capacity, economic returns, and above all, the environmental services. The model designs and preferences may be need (Product) specific, economic value specific, site specific, cultural value specific, technology specific and combination specific. The paper discusses the need to incorporate the design specificities in agroforestry models because of their importance in participatory forest management and regional planning in India.

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अलिन्द रस्तोगी व एस० श्रीनिवास

सारांश

किसी भी कृषिवानिकी प्रतिदर्श को लोकप्रिय बनाने के लिए उसका आकल्प एक रणनीलिक उपकरण होता है । वैज्ञानिकों की सूचनात्मक संभावनाओं का केन्द्र अभियान्त्रिकीय मूल्य, आकल्प को इष्टतम बनाने की, विधियों, श्रम लगने के विचारों, वृक्ष-फसल की परस्पर प्रतिक्रियाओं के संश्रम संयोगों, आकल्प में नवीनताओं की आवश्यकताओं पर आधारित प्रतिदर्शों का विकास, स्थान की क्षमताओं, आर्थिक प्रत्याय और इन सबसे बढ़कर पर्यावरण सेवाओं पर ही बना रहेगा । प्रतिदर्श-आकल्प और उनकी पसन्दगी आवश्यकता के अनुसार विशिष्ट अथवा आर्थिक मूल्य विशिष्ट , स्थान विशिष्ट , सांस्कृतिक मूल्य विशिष्ट , प्रौद्योगिकी विशिष्ट , और संयोग विशिष्ट हो सकते हैं । प्रस्तुत अभिपत्र में कृषि वानिकी प्रतिदर्शों में आकल्पों की विशिष्टताओं को सम्मिलित करने की आवश्यकता का विवेचन किया गया है क्योंकि भारत में सहयोगांत्मक वन प्रबन्ध और क्षेत्रीय आयोजना कार्यों में इनका बहुत महत्त्व है ।

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FINANCIAL ANALYSIS OF BAMBOO BASED AGROFORESTRY MODELS

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Introduction

Demand for bamboo is increasing both from industries as well as for commercial purposes. Natural forests have been the main source of bamboos so far but over exploitation of these forests has led to decease in its production. Scenario of increasing demand, decreasing supply, assured marketability makes cultivation of bamboo on private lands an attractive economic proposition. Agroforestry practice of bamboo cultivation may bring fairly high returns to the farmers. At present, bamboo based agroforestry practice is not very common, the reason being, lack of adequate technical and economic information and almost non-existent field demonstrations.

In this paper, analysis of financial profitability from agroforestry practices of bamboo cultivation has been examined. Economic returns from three agroforestry models of bamboo cultivation have been simulated on agricultural lands of varying productivity.

Methodology

(a) The analysis has been carried out for three systems having spacing of bamboo clumps as 3 m x 4 m, 4 m x 5 m and 5 m x 6 m.

(b) Lands of varying agricultural productivity have been taken into consideration. Agricultural productivity has been valued in terms of net annual agricultural income from the land, which depends on factors such as fertility of soil, irrigation, number of crops in a year, other inputs, enterprising ability of farmer, cultivation of any cash crop etc. Lands generating net annual agricultural income of Rs. 3000/ha to Rs. 31000/ha have been considered in the study. From the point of view of agricultural value, the lands have been classified as low, medium and high.

Low - Rs. 3000/ha to Rs. 9000/ha
Medium - Rs. 9000/ha to Rs. 19000/ha
High - Rs. 19000/ha to Rs. 31000/ha

(c) The model envisages retention of bamboo plants for 15 years to allow farmer to switch over to any other crop system of his choice which may offer better returns to him.

(d) Economic analysis has been carried out by writing a computer programme in BASIC language. The programme offers flexibility in choosing different values of discount rate, radius of the clump or of any other variable.

(e) For simulating economic returns yield, price, and other data have been taken as follows :

(i) Yield of bamboo will start from 6th year, every year 5 culms will be removed from each clump.

(ii) Average height of culms from the clumps of increasing spacing are :
3m x 4m 3.6m
4m x 5m 4.2m
5m x 6m 4.8m (based on field observation)

(iii) Yield of bamboo has been assumed to increase with increasing agricultural value of land upto the land value of Rs. 13000/-. The rate of increase in height of culms has been assumed to be 0.05m per Rs. 1000/- increase in agricultural value of land.

(iv) Establishment cost :
Digging of pits - Rs. 2.5/pit
Seedlings - Re. 1/- seedling (based on work study)
Farm yard manure - Rs. 0.30/pit
Planting - Rs. 0.35/seedling

(v) Soil mounting on clumps in 5th year - Rs. 6/clump (based on work study).

(vi) Cost in uprooting clumps - Rs. 8/clump (based on work study)

(vii) Net revenue from bamboo (at the field, after paying harvesting cost and excluding transportation charges) - Rs. 800/notional tonne.

(viii) Radius of bamboo clumps of 6 to 15 years of age - 0.6 to 0.9 m (it has been assumed that by yearly removal of bamboo at the rate of 5 culms/clump, radius of the clumps will be contained at a fixed length).

(f) Loss of agricultural crop production due to occupied area under bamboo clumps is a cost for cultivation of bamboo, this cost has been termed as Sacrificed Agricultural Income (SAI) in the analysis. Since production from the bamboo plantation starts from 6th year, SAI from 1st year to 5th year has been treated as fixed deposited in bank in the respective years. This has been done to take into account opportunity cost of the agricultural income i.e., had bamboo plantation not taken place.

(g) Annual rate of increase in the real prices of agricultural produce and bamboo has been assumed to be 2% p.a., while value of money under fixed-deposit has been assumed to grow at the real rate of 4% p.a.

(h) Analysis has been carried out at discount rate 8.0% p.a.

Analysis

(a) The analysis gives values of Net Present Value (NPV) and Internal Rate of Return (IRR) for the agroforestry models in question (Table 1). This provides a basis for comparing alternative land uses.

(b) It is seen in the table that NPV and IRR are higher for the lands of low agricultural value. This is due to the fact that sacrificed agricultural income on those lands is low. Thus agroforestry system of bamboo cultivation can economically be one of the most efficient system of landuse on such lands.

(c) The Table 1 shows that on the lands of higher agricultural value (AI more than 15000) larger spacing i.e. 4m x 5m and 5m x 6m become economically more attractive, however the enterprise becomes economically unviable at further higher values of agricultural lands (IRR less than 14% can be taken as unviable project) (Fig. 1 and 2).

Fig. 1

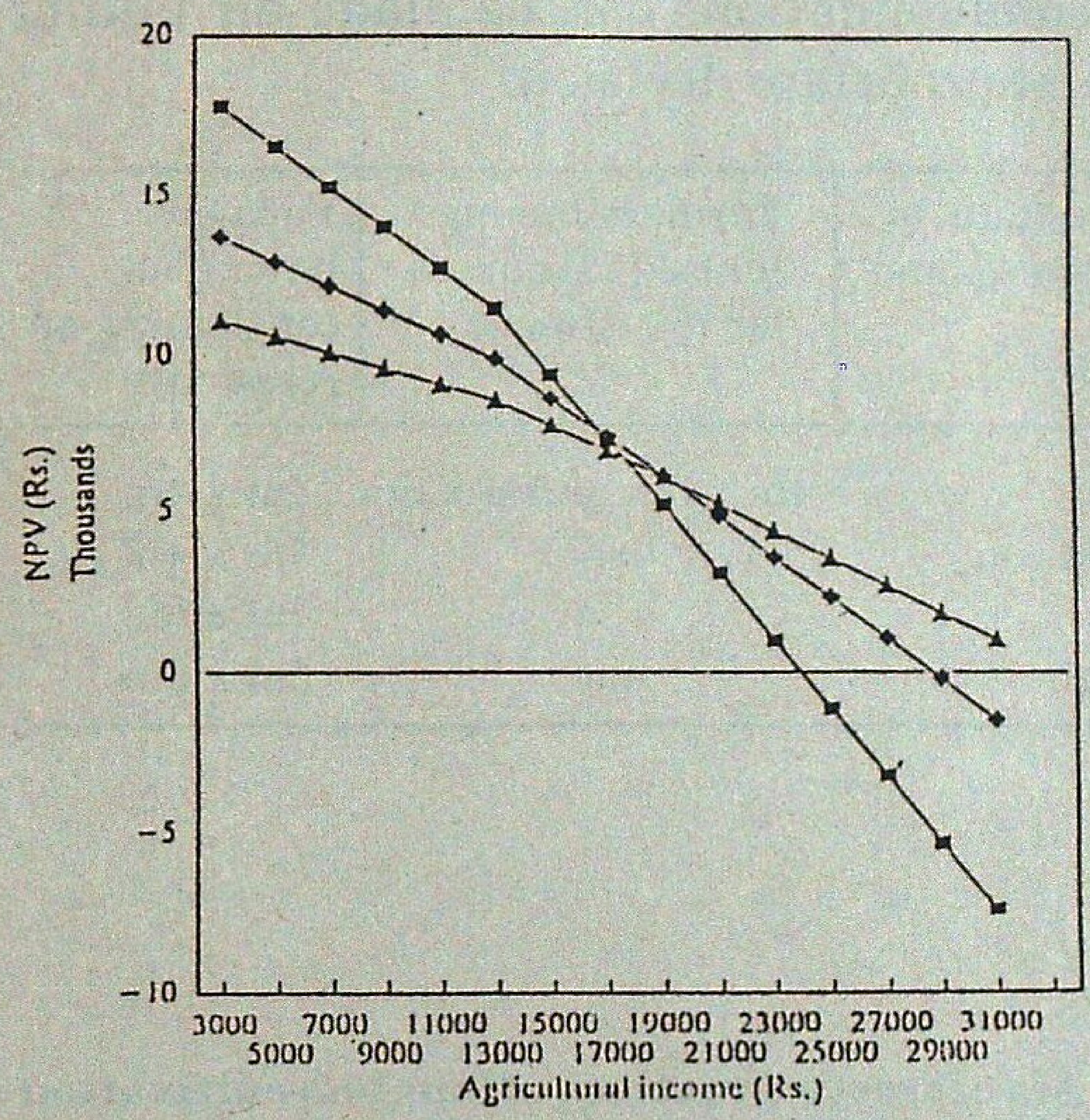
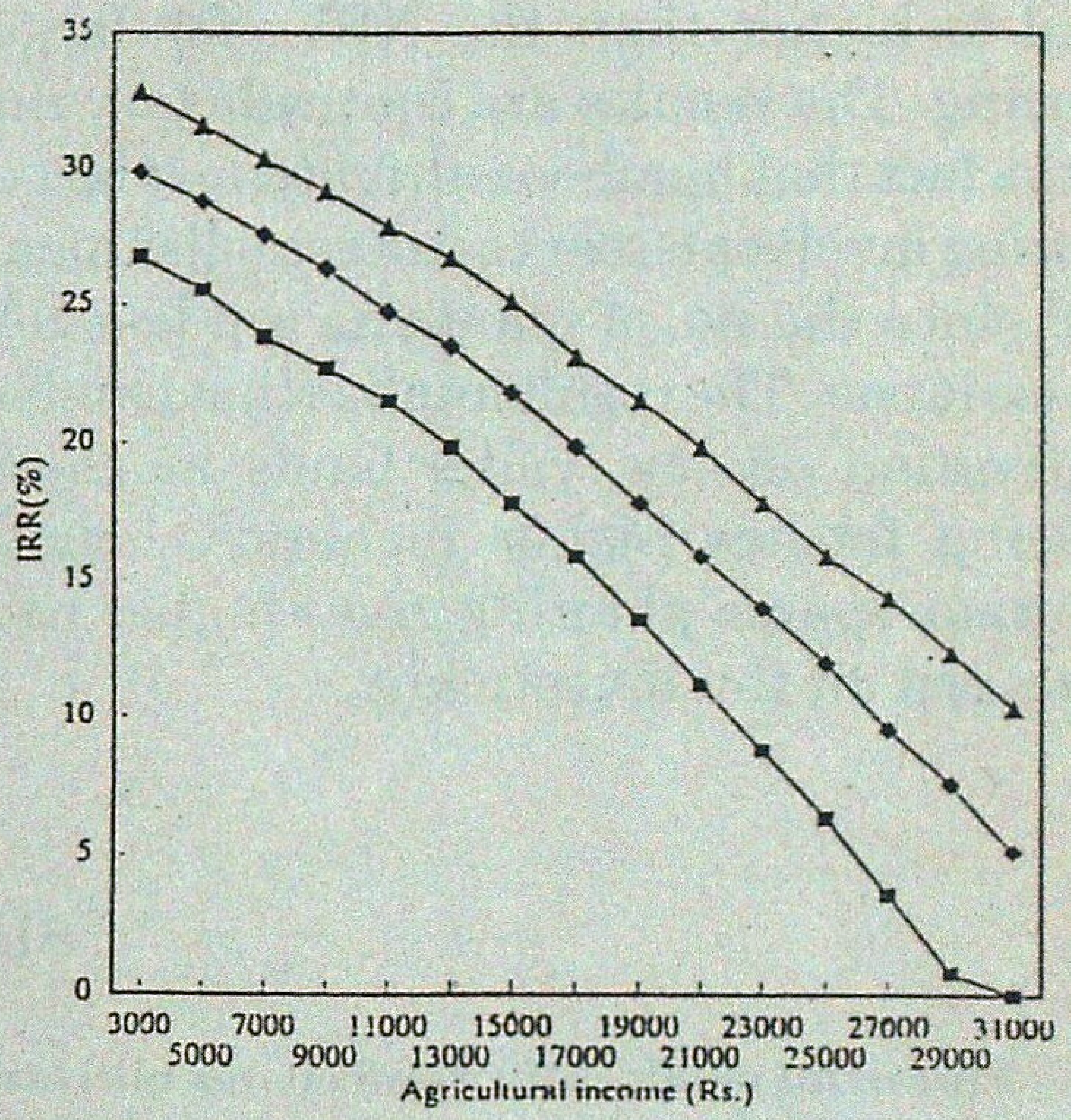


Fig. 2



■ 3m x 4m ◆ 4m x 5m ▲ 5m x 6m

Table 1

NPV and IRR of Bamboo agroforestry models

Radius of clump = 0.75m,
Discount Rate = 8.0% p.a.

Agricultural income	Spacing					
	3 m x 4 m		4 m x 5 m		5 m x 6 m	
	NPV	IRR	NPV	IRR	NPV	IRR
3000	17792	26.8	13673	29.9	11099	32.8
5000	16527	25.6	12913	28.8	10593	31.6
7000	15261	23.9	12153	27.6	10087	30.4
9000	13995	22.8	11394	26.4	9581	29.2
11000	12730	21.6	10634	24.8	9076	27.9
13000	11464	19.9	9874	23.6	8570	26.8
15000	9368	17.9	8616	21.9	7732	25.2
17000	7272	15.9	7358	19.9	6893	23.2
19000	5175	13.6	6099	17.9	6055	21.6
21000	3079	11.2	4841	15.9	5217	19.9
23000	982	8.8	3582	14.0	4379	17.9
25000	-1114	6.4	2324	12.0	3541	15.9
27000	-3211	3.6	1066	9.6	2703	14.4
29000	-5307	0.8	-193	7.6	1864	12.4
31000	-7403	0.0	-1451	5.2	1027	10.4

(d) IRR is always higher in case of larger spacing but NPV for low agricultural value land is higher than the NPVs for larger spacing. The results are contradictory due to the fact that bamboo cultivation at larger spacing involves lesser cost of establishment, and since the no. of plants/ha are less SAI is also lesser. The result implies that bamboo cultivation on low value lands at closer spacing fetches higher monetary benefit whereas sparse planting gives higher rate of return on the investment.

On the basis of above analysis following recommendations can be made for taking an appropriate decision.

Agricultural value of land	Farmers having limited resources for investment	Farmers having no constraints on resources
Low	4m x 5m or 5m x 6m	3m x 4m
Medium	-do-	3m x 4m or 4m x 5m
High	-do-	5m x 6m

SUMMARY

Financial profitability and economic returns from Agroforesty practices of bamboo cultivation has been discussed in this paper.

बांसों पर आधारित कृषिवानिकी प्रतिदर्शों का वित्तीय विश्लेषण

एस० आशुतोष, परेश विश्वकर्मा व शरद नेमा

सारांश

प्रस्तुत अभिपत्र में बांसों को रोपने से संबन्धित कृषिवानिकी प्रक्रियाओं से मिल सकने वाली आर्थिक प्रत्याय और उनकी वित्तीय लाभप्रदता का विवेचन किया गया है ।

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AGROFORESTRY IN FARMING SYSTEMS DEVELOPMENT

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Introduction

Agroforestry research in India was initiated during sixties by Forest Research Institute, Dehra Dun and State Forest Departments mainly to develop potential technologies in areas like Shifting cultivation, Taungya system, Agri-silviculture and tree farming. During seventies research activities further expanded to study precisely various factors like soil, moisture, microclimate, nutrients, biomass, energy, tree-crop interaction, choice of species, tree improvement and socio-economic considerations etc. Despite importance of agroforestry, not much attention has been paid to make it a science-based, more compatible and remunerative system. Data are lacking on tree-crop interaction and different benefits both direct and indirect accruing form such combinations under varied local conditions. Since the research efforts undertaken on forest trees on one side and annual crops on the other, have been largely in isolation, the findings are not directly applicable to agroforestry systems. Secondly the studies conducted so far in agroforestry are localized and have no wider application. In recognition of this lacuna, Indian Council of Forestry Research and Education (ICFRE), Dehra Dun has taken up agroforestry research.

Traditional Agroforestry Practices

In India agroforestry traditionally practiced in various forms which can broadly be categorised into two categories viz., Forest Based Agroforestry practices and Farm Based Agroforestry practices. In Forest based agroforestry approach the forms and practices includes : Shifting cultivation, Taungya system, Lease system. In Farm based agroforestry approach the practices includes *Prosopis cineraria* based system, cocoa based system, homestead system, alley cropping system and shelterbelt and windbreaks.

In arid and semi-arid areas of Rajasthan, Haryana and Gujarat tree species like *Prosopis cineraria, Tamarix aphylla, Zizyphus* spp., *Tecomella undulata* are grown traditionally as scattered trees, within the cultivated fields and along field boundaries. *Prosopis cineraria* and *Zizyphus mauritiana* are considered most promising multipurpose trees species. It adds high amount of leaf litter to the soil which resulted increase in soil organic matter and nitrogen content, an increased availability of micro-nutrients (Zn, Mn and Cu) and higher moisture availability in the surface soil layer (Aggarwal, 1980). In the plains region of Punjab, Haryana, J & K, H.P. and Uttar Pradesh, species grown as scattered trees and on field boundaries include *Acacia nilotica, Dalbergia sissoo, Azadirachta indica, Morus alba.* There is a long standing tradition of practicing coconut based system in Kerala. An important aspect that has been reported (Nair, 1979) is that the presence of more plant cover on the plantation floor increases the fraction of nutrients that is cycled within the soil-plant system. In Western Himalayan region *Celtis australis, Grewia optiwa, Alnus nitida, Populus ciliata, P. nigra* ad *Salix alba* have been grown on field margins.

In pursuance of the recommendations of the NCA systematic agroforestry programmes were initiated during 1970s to meet fuelwood and fodder needs for self consumption of rural households, thus relieve pressure on forests.

The area under privately owned trees crops and groves in the country was about 2.77% of the total reporting area during 1951-52. During 1980 to 88 farmers in India raised about 10550 million trees on private lands (Chambers *et al.,* 1989). As regards species planted, *Eucalyptus* hybrid *(E. tereticornis), Populus deltoides, Acacia tortilis, Casuarina equisetifolia, Leucaena leucocephala, Dalbergia sissoo, Anthocephalus chinensis,* Bamboos etc. are the most favoured tree species with the farmers.

Agroforestry as a Land Management Alternative

Bene *et al.* (1977) defined agroforestry which has become basis for scientific study. "Agroforestry is a sustainable management system for land that increases total production, combines agricultural crops, tree crops and forest plants and or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population".

Several basic ideas for study can be drawn from this definition :

(i) Agroforestry is a practice of managing or using land (i.e., a land-use system) that combines trees or shrubs with agricultural or horticultural crops or livestock.

(ii) Agroforestry integrates trees with crops and/or animals, with the main objective of reducing risk and increasing total productivity. In India farmers traditionally used mixed cropping practices to minimize the risk of total crop failure by growing variety of products in one time on the same piece of land.

(iii) Agroforestry systems are both stable and sustainable. Such practices have greater diversity than do monoculture practices and can distribute production over a longer period of time.

(iv) Sustainability, or the ability to maintain productivity over time, is also a common feature. Agroforestry systems improve soil physical properties., maintain soil organic matter and promote nutrient cycling are considered to be the strong aspects for sustainability.

(v) Integration of trees into agricultural systems provide more efficient use of sunlight, moisture and plant nutrients as compared to monocropping of either agriculture or forestry crops. One of the biological reasons for interest in agroforestry is that trees use portions of the biosphere that annual crops generally do not, resulting in increased aggregate biomass production.

(vi) Thus agroforestry is a multiple use concept of land management and is capable of meeting the present challenge of shortages of fuelwood, fodder, fibre, timber, unemployment, environmental degradation, protection and improvement of wastelands and agricultural land.

Sustainable considerations

Previous experience show that this choice i.e. integration of trees into agriculture system is possible and suitable to farming systems in India to take large scale plantations to restore forest coverage and achieve the objectives of sustainability, increased production, benefit the farmers and rural poor in general. In all consideration must be given to the goal of sustainability if improved agroforestry practices or management is to be successful in helping farmers to improve their long-term well being.

- Vegetative cover is maintained to reduce soil erosion risks.
- The nutrient cycle is be managed so that nutrient losses are balanced with nutrient additions.
- Crop nutrient cycling characteristics are regulated or latered to nutrient input level from rain, dust, nitrogen fixation and weathering.
- Biotic diversity of species composition, age distribution, trophic levels, and so on is sustained above the level at which the activities of pests and diseases become an ecological and economic constraint.

Development of Agroforestry technologies

Agroforestry is the concept that builds on a synthesis of much of the practical experience and scientific knowledge acquired over the past decades in agriculture, forestry, ecology, soil science and rural socio-economics. From the preceding discussion it is clear that concept and word of agroforestry is not new. Lundgren (1987) discussed that the concept of optimization of the production of various products and services, with minimum risk, from a unit of land, as opposed to maximization of a single commodity in monocultural production systems is perhaps new in agroforestry as we know it today. The concerted effort to develop agroforestry as a sustainable approach to land management gathered momentum only in the seventies and it was institutionalized with the establishment of ICRAF in 1977. The development in agroforestry all over world particularly in tropical countries have been substantial since then. The new technologies developed in agroforestry trials or in related disciplines being incorporated in agroforestry are discussed below :

Shifting Cultivation : In India it is extensively practiced in the north-eastern hill region, Andhra Pradesh, Bihar, Madhya Pradesh, Orissa and Karnataka States. In earlier decades the shifting cultivation cycle was about 30 to 40 years which has come down to 5-7 years, hardly sufficient for rebuilding soil fertility. The reason being steady rise in the population. Due to decline in cycle, there is a tremendous decline in the yield of crops, soil fertility, ecological aspects and economic conditions. Shifting cultivation practice is a major cause of soil erosion. The annual soil loss is reported to vary widely from 3.3 to 201 tonnes/ha (Singh and Singh, 1981). Singh (1981) has suggested the following Silvi-agri-horticulture model as an alternative to shifting cultivation.

Part of slope	App. % of total area	Suggested land use	Conservation measures
Top portion	35	Forestry	-
Middle portion	30	Horticulture	Half moon terracing
Lower portion	30	Agriculture	Bench terracing
Valley	5	Agriculture pisciculture	Level terraces ponds

Another alternative system is practicing home gardens. This system is extensively practiced on the plain lands in Kerala and is often coconut-based. However, in the north-eastern hills arecanut, betel leaf, banana and black pepper are grown together and also as an intercrop. The success of these alternatives i.e. settled agriculture mainly depend on peoples acceptance, addressing land tenure and ownership aspects. The Philippines "Sloping Agricultural Land Technology (SALT)" is another innovation in which *Leucaena* and *Gliricidia* are planted as hedge rows and the interspaces are utilized for cultivating agricultural crops. In another model known as SALT II integrates goat production by cultivating agricultural and fodder crops. The ratio of crops, trees and fodder is 40 : 20 : 40. In SALT III model only trees and food crops are integrated in a ratio of 60 : 40 (Tejwani, 1994).

Soil improvement under Agroforestry : Planting of trees under agroforestry brings about improvement in soil properties through root activity, addition of organic matter, nutrient cycling and nitrogen fixation. Most of the agroforestry research on green manuring involves alley cropping with leguminous trees. The green biomass obtained from trees/shrubs through different levels of pruning is applied to the associated crop growing between rows of trees as a source of organic matter and nutrient application. Tree species like *Casuarina, Leucaena, Prosopis cineraria, Acacia nilotica* and *Sesbania grandiflora* etc grown under agroforestry are endowed with the ability of fixing atmospheric nitrogen. *Leucaena* is reported to fix as much as 350 kg N per ha annually. Kang *et al.* (1981) reported that *Leucaena* pruning yielded large quantities of N i.e. 180 kg to 240 kg/ha, but that the efficiency with which the associated maize crop could use the N from the prunings was low compared to its use of N fertilizer. An increase in the amount of organic matter, nitrogen and phosphorus was found as 0.57%, 0.042% and 0.425% in the upper soil surface (0-15 cm) under 14 year old *Prosopis cineraria* trees as compared to bare field; 0.37%, 0.020 and 0.287, respectively. Application of eight tonnes of *Leucaena* leaves per hectare to rice crop produced results comparable to application of 69 kg per ha of commercial nitrogen fertilizer, rice yields increased by 89 per cent (Vergera, 1982). Leguminous trees which may be considered better proposition for inclusion are *Sesbania, Leucaena, Gliricidia, Acacia, Prosopis, Albizia, Cassia, Erythrina, Calliandra, Pithecellobium* etc. The quantities of nitrogen fixation per ha/yr *Leucaena* is upto 500 kg, *Acacia* 270 kg and non-legumes like *Alnus* upto 300 kg are reported (Vergera, 1982; Mishra, 1986).

It is now well documented that Mycorrhizae, which are a range of symbiotic associations between soil, fungi and plant roots, improve the uptake of a range of macronutrients, especially immobile phosphorus. The mycorrhizal association improves uptake of micronutrients such as zinc and copper, enhance nitrogen fixation by *Rhizobium* and Frankia, and have been associated with the reduction of disease susceptibility (Gilmore, 1971; Daft *et al.*, 1985). Two types of mycorrhiza are relevant to agroforestry - ectomycorrhiza, endomycorrhiza.

Agroforestry systems are considered to be superior to other cropping systems with respect to erosion protection because trees protect the soil against erosion more efficiently. The range of erosion observed in different systems (Table 1) indicated several important factors that affect the rate of erosion, most notably the effect of the inclusion of annual crops in sequential agroforestry system and the presence or absence of a protective plant cover directly on the soil surface (Wiersum, 1984).

On a marginal land in North-western Himalayan region at Dehra Dun, growing of trees (*Eucalyptus, Leucaena*) and grass (*Chrysopogon fulvus*) along with cereal crops (wheat, maize) reduced the run-off and soil loss substantially, the reduction being more under *Eucalyptus* than under *Luecaena* (Narain *et al.*, 1988). The soil loss of 47 t/ha in cultivated fallow decreased to 0.9 to 5.0 t/ha under maize + *Eucalyptus* and maize + *Leucaena*, respectively. Likewise, the run-off 26 per cent of the rainfall in cultivated fallow was reduced to 3.6 and 8.9 per cent under maize + *Eucalyptus* and maize + *Leucanena*, respectively.

Salt affected soils which are lying barren for decades and occupy vast exposure in India, offer good possibilities. Work done ion afforestation of salt affected soils has been reviewed by Yadav (1980), Kumar (1988) and Kumar & Abrol (1984). In latest studies it has been shown that Karnal grass (*Diglachne fusca*), Para grass (*Brachiaria mitica*) and Rodos grass (*Chloris gayana*) are relatively high tolerant to sodic soils.

Kaushik *et al.* (1969) found that in Haryana and Punjab *Eucalyptus* hybrid grew satisfactorily on soils having pH less than 9 and soluble salts upto 0.3 per cent. In Tamil Nadu, *Atriplex repens* is commonly found on some saline areas. Garg and Khanduja (1979) reported the success of *Pongamia pinnata* and *Terminalia arjuna* on soils with pH 9.0 and of *Acacia nilotica* on soils with pH upto 9.6. Yadav (1980) observed that *Prosopis juliflora, Eucalyptus* hybrid and *Acacia nilotica* can be grown on calcareous sodic soils. Gill and Abrol (1983, 1987) and Grewal and Abrol (1986, 1987) reported that *Casuarina equisetifolia* and *Acacia nilotica* are the promising species for highly sodic soils. Chaturvedi (1984) reported that *Eucalyptus* hybrid grows well in the first year as long as the roots are confined to the top layer of sandy soil. However, growth stagnates when its roots reach the clay layers.

Tree selection and improvement : Choosing and improving species for agroforestry is complicated because the tree is expected to

Table 1

Rates of erosion in various tropical forest and agroforestry systems (t/ha/yr)

	Minimal	Median	Maximal
Multistoried trees gardens (4/4)*	0.01	0.06	0.14
Natural forests (18/27)	0.03	0.30	6.16
Shifting cultivation fallow period (6/14)	0.05	0.15	7.40
Forest plantations, undisturbed (14/20)	0.02	0.15	7.40
Tree crops with cover corp/mulch (9/17)	0.10	0.75	5.60
Shifting cultivation, cropping period (7/22)	0.40	2.78	70.05
Taungya cultivation (2/6)	0.63	5.23	17.37
Tree crops, clean-weeded (10/17)	1.20	47.60	182.90
Forest plantations, burned/litter removed (7/7)	5.92	53.40	104.80

* (x/y), x = no. of locations, y = no. of treatments/observations, Adapted from : Wiersum, 1984.

fulfill poorly defined functions and because the desired traits for agroforestry are seldom evaluated. Choice of species for agroforestry requires careful review of these basic questions :

- What are the intended uses of the planting, both immediate and future?
- Are potentially promising species available?
- What are the quality and condition of the planting sites?
- Will the tree be used in combination with crop and livestock?
- How will the trees most likely be managed?

In India, several tree species have shown promise and extensively grown under agroforestry conditions include: *Eucalyptus* spp., *Casuarina equisetifolia, Acacia nilotica, Tectona grandis, Leucaena leucocephala,* Bamboos, *Cocos nucifera, Syzygium cumini, Grewia optiva, Alnus nepalensis* and *Salix* spp. However, tree improvement programme conducted only for the species viz., *Eucalyptus, Populus, Salix, Leucaena* and *Tectona grandis* etc.

Tree improvement for agroforestry differs in two important ways from traditional practices. First, species selection should be made under agroforestry conditions, not plantation conditions. If trees are to interact positively with crops or livestock, they should be tested and selected under those conditions. For example, if an objective of tree improvement is to produce faster-growing trees that will grow with paddy rice, then selection should be made using paddy rice conditions. While it is both difficult and expensive to include intercropped annuals in experiments for selection, such trials should also be considered if increases in total productivity are desired.

Second, there are tree species potentially available for testing that have already been under some selective pressure on farms. Improvement programs for plantation tree species are generally conducted only by government, quasi-government, or private sector organizations, but many agroforestry species already have been selected and tested by farmers themselves.

Forest Scientists of ICFRE have adopted several strategies which include species and provenance trials, selection of candidates plus trees based on their phenotypic features and their evaluation by progeny tests or directly by clonal testing, creating seed production areas by upgrading superior stands through the removal of inferior looking trees, establishment of seedling, seed orchards and clonal seed orchards for the supply of superior quality seed, and mass production of superior clonal material through vegetative propagation using the traditional methods of rooting cuttings as well as the more recently developed *in-vitro* techniques for raising clonal plantations of outstanding clones of agroforestry trees. The research efforts and achievements in the yield improvement of some of the important agroforestry tree species have benefited the farmers/tree planters. In Aracruz (Brazil), clonal selection of *Eucalyptus grandis* enhanced productivity as high as 113 m^3/ha/yr is some selected clones and on an average to 70 m^3/ha/yr (Brandeo *et al.*, 1984).

Effect of tree planting under Agroforestry conditions : At times the tree planting is beneficial to the associated crop and cases of adverse effects are also reported. It has been observed that rate of growth of trees under agroforestry condition is much faster. Fotidar (1970) reported that yield from poplar raised under agroforestry varies from 10 m^3/ha/yr to 25 m^3/ha/yr. Kaul and Sharma, (1983) while studying the *Populus deltoides* plantation of different age, under agroforestry conditions reported that total biomass under different ages varied from 86 t/ha to 126 t/ha. Dwivedi *et al.* (1990) reported that above ground biomass (dry/t/ha) of 2, 3, 4, 5 and 6 yrs old bund plantation of *P. deltoides* is of the order of 0.78, 0.88, 6.88, 8.37 and 10.50 respectively while of *Eucalyptus* of 5 and 6 year old one side bund plantation 5.49 and 6.74, respectively. The total biomass (dt/ha) of 2, 3 and 5 years old block plantation of *P. deltoides* is 15.635, 64.820 and 110.289, respectively. They further discussed that a growing stock of 1.5 m^3/ha/yr to 3.5 m^3/ha/yr can easily be obtained from field bund plantations which is much more than average productivity of forests. The productivity from block plantations of poplar is many times more and ranged from 20-28 m^3/ha/annum. Mathur *et al.* (1984) discussed the economic feasibility of *Eucalyptus* raised on field bunds in Punjab, Haryana and reported that the net present value in U.P. was Rs. 34,371 at 10 year rotation and Rs. 22,556 at 8 year rotation on 10 per cent rate of interest. Mathur and Sharma (1983) studying net income from block plantation of poplars with agriculture crops concluded that poplar cultivation on agriculture fields is profitable. Similar effects of tree planting under agroforestry conditions have also been reported by many workers such as Patil *et al.* (1979), Gupta *et al.* (1982), Mangrulkar, (1981), Dhillon *et al.* (1979, 1982), Khybri *et al.* (1983), Kumar (1984) and Srivastava and Narain (1980).

Utilization : A great deal of research work has been carried out at the Forest Research Institute, Dehra Dun on the utilization of plantation grown materials. Sawing and seasoning techniques have been evolved for *Eucalyptus* and poplars which to a great extent have helped in promoting these species for variety of uses. Ammonia fumigation technique helps in upbringing of figures and texture in most of the plain looking timbers like *Eucalyptus*. Technique also helps in developing permanent stains in wood and wide range of shades can also be developed to match conventional timbers like sissoo and rosewood. Ammonia treatment technique also helps in plasticization of timbers and bentwood furniture can be made avoiding wastage during shaping. Recently at the Forest Research Institute, Dehra Dun reconstituted wood from bamboo has been developed by reconstituting destructured green bamboo with suitable adhesive without disturbing the natural alignment of fibres thus retaining the directional strength properties of bamboo. The sequence of sawing disbalances the stresses, resulting in immediate warping (bow) and spring of *Eucalyptus* timber as it comes out of the saw. Warping on the saw has been found to be appreciably minimised by balanced Tangential sawing procedure due to balanced sequences of cuts. Schedule for drying of 25 mm thick plank through kiln seasoning has been evolved. A combined moisture conditioning and stress relief treatment is an essential part of kiln drying practices for *E. tereticornis*. It has been found that nearly 4 hr steaming at 55°C at the final stage of drying is essential for removing the stresses in 25 mm planks. Suitability of *Populus deltoides* was studied for making compressed wood shuttle blocks. Peeling characteristics of *Populus deltoides* have been studied for obtaining smooth, uniform, tight and strong veneers. Optimum conditions determined for peeling 1.61 mm thick veneers are Temperature of Log conditioning 55°C, Speed of peeling 45.72 m/min., Horizontal gap and Vertical gap between knife and pressure bar 1.524 mm and 0.38 mm, respectively. Suitability of *Populus deltoides* was studied for various grades of plywood and blockboards using UF and PF glue. Poplar is suitable for general purpose plywood, marine plywood, concrete shuttering plywood, blockboards, preservative treated plywood and fire retardant plywood. Suitability of young *P. deltoides* plants 1 and 2 year old was evaluated for making fibre hardboards. *Populus deltoides* was found suitable for the manufacture of wood cement composites by incorporating calcium chloride as an accelerator. Destructure reconstituted wood has been developed from lops and tops of *Populus deltoides* for structural purposes using PF adhesives.

Models

Prosopis cineraria based Agroforestry models : Its suitability in agroforestry system stems from the amazing capacity of a well lopped "Khejri" tree to recover the full crown size in a period of nine months. A khejri tree has fully developed crown by the end of September, coinciding with the maturity of 'Kharif crops. Thus the foliage at this point of time is lopped to facilitate better growth of 'Kharif' crop. In case, the fields are to be used for 'Rabi' crops like wheat and mustard, lopping continues slowly during summers and develops fast during monsoon. Various agroforestry system based on *Prosopis cineraria* and their economic return are given in Table 2.

Dalbergia sissoo based Agroforestry models : *Dalbergia sissoo* Roxb. has been widely planted traditionally by farmers in most parts of India under irrigated and rainfed conditions for their requirements like timber, small timber and firewood, etc. It has been reported that nutrient concentration in the leaves in a 24 year old plantation was found as Ca 3.5%, N 2.55%, K 0.63%, Mg 0.3% and P 0.1%. The litter fall is reported to commence during October and continued to January, about 99% of litter falls on the ground by January end. The annual litter production of *D. sissoo* plantation on unit area basis worked out to be 4164 kg/ha, out of which leaf litter accounted for 89% (3714 kg/ha). The litter decomposition takes place w.e.f. October and continued till April. Most of the litter that decomposed, is mineralized and recycled. The falling foliage decomposes quickly and the released nutrients are readily available to the establishing

Table 2

Estimated economic returns from Prosopis cineraria - Model of agroforestry

System	Yield (q/ha)					Total sole crop (Rs/yr/ha)	Return over (Rs/yr/ha)
	Grain	Straw	Tree Fodder	Fuel	Pods		
P. cineraria Pearlmillet	15.0	60	10	20	5	15,000	4,500
P. cineraria Moongbean	10.0	12.0	10	20	5	15,460	4,500
P. cineraria Clusterbean	8.0	12.0	10	20	5	8,500	4,500

agricultural crops. These nutrients are in addition to nitrogen fixed biologically by the trees and have beneficial effect on the production of agriculture crops.

Agroforestry studies using *Dalbergia sissoo* were conducted at FRI, Dehra Dun to assess the crop productivity under semi-arid conditions. Growth performance of *D. sissoo* trees intercropped with wheat and paddy showed mean height and gbh as 10.36m and 53.45 cm, total timber 1.2554 m^3, small timber 7.0899 m^3 and fuelwood 77.45 q. The gross income from trees calculated as Rs. 24,056 for 33 trees per 55 m tree line. Crop yields and other crop parameters of wheat especially under tree canopy upto 4 m from tree line declined significantly. In case of paddy such influence was found upto 8 m from tree row. The total affected area in the entire plot worked out to 220 m^2 in wheat crop and 440 m^2 (Rs 53) and 101.20 kg (Rs. 559), respectively. The losses to agriculture crops are well compensated by the gross income Rs. 2005/acre/yr obtained through sale of trees.

Under agroforestry conditions, this species has been raised as boundary plantations, as windbreaks around orchards, as shelterbelts in arid areas and as single scattered trees retained in agriculture fields.

Eucalyptus based Agroforestry models : Over the years *Eucalyptus* trees have been grown in association with agricultural crops, as windbreak around orchards, as avenue tree on farm houses, cattleshed and as roadside avenue on farm approach road, Raising of *Eucalyptus* on field boundaries under different pattern of plants is a common practice adopted by farmers. It has been observed that at times *Eucalyptus* planting is beneficial to the associated crop. However, cases of adverse effects are also reported. The economic feasibility of *Eucalyptus* hybrid both with or without agriculture under varying spacing viz. 2.5m x 2.5m, 3.0m x 1.5m, 4.0m x 2.0m and 6.0m x 1.0m was worked out (Mathur *et al.*, 1984). The results of the studies indicate that cultivation of *Eucalyptus* at wider spacing (6.0m x 1.0m) with a rotation of 8 years in combination with agricultural crops on farm lands in U.P. has given maximum Net Present Value (NPV) of Rs. 18,702 and Benefit Cost ratio (B:C) of 2.28. In Punjab/Haryana with the same practice the NPV and B:C ratio were also found maximum, i.e. Rs. 17,072 and 2.17, respectively. This revealed that *Eucalyptus* grown on farm lands at 6.0m x 1.0m spacing with a rotation of 8 years is profitable. Though the Internal Rate of Return (IRR) was found higher by 96 per cent for 4.0m x 2.0m spacing with intercropping at 8 years rotation, this is because of difference in planting cost which was lowest in 4.0m x 2.0m spacing. For small farmers planting of *Eucalyptus* on field bunds was found economically viable and thus recommended. In pure plantations, *Eucalyptus* grown at 2.5m x 2.5m spacing with three coppice crops on 8 years rotation with 12 per cent rate of interest gave significantly higher net returns as compared to other spacing. However, *Eucalyptus* grown on field bunds in Uttar Pradesh, Punjab/Haryana gave highest NPV at 10 and 8 year rotation i.e. Rs. 34,371 and Rs. 31,681 as compared to *Eucalyptus* grown in block planting both with and without intercropping.

The influence of *Eucalyptus* trees grown as single row on one side of the field in East-West direction on the growth and yield of wheat was studied in Haryana (Sharma, 1990). The results of the study revealed that all the crop parameters viz crop height (cm), plant density/m^2, ear length (cm) and grain yield (q/ha) showed poor performance in the vicinity of tree line upto 4 m, probably due to suppressing effect of trees. The growth and yield of wheat increases numerically as the distance from tree line increases. The loss in wheat production in the affected area (480 m^2) in 0.4 ha plot worked out to 24.96 kg (net loss of Rs. 60/- only). *Eucalyptus* trees gave a gain of Rs. 242 per year or Rs. 1,452.82 for 41 trees per 55m tree line at 6 years rotation. In another study to see the effect of *Eucalyptus* tree row grown on two sides of the field on the growth and yield of wheat crop indicated a loss of about 60 per cent to agriculture crop at six years age while trees grown on all sides had pronounced effect on the entire crop in the field.

Dwivedi *et al.* (1990) studied the growth performance and biomass production of *Eucalyptus tereticornis* (*E.* hybrid) trees grown on agriculture field bunds. The above ground biomass (dt/ha) of *E. tereticornis* at 6 years age grown on two sides and all sides of the field boundary in single row produces above ground biomass (dt/ha) of the order of 16.62 and 27.22, respectively. They concluded that the measurements in case of field bund plantation revealed that growing stock of 1.5 m^3/ha/yr to 3.5 m^3/ha/yr can easily be obtained which is much more than the average productivity of 0.7 m^3/ha/yr of Forest Department.

Poplar based Agroforestry models : The characteristics of poplars having straight clean bole, leafless during winter months, combining well with agriculture crops, good economic returns in short rotation i.e. 6-8 years and availability of bank loans have made versatile poplars the most popular tree species for planting under agroforestry systems in the State of Punjab, Haryana, Uttar Pradesh, Himachal Pradesh and Arunachal Pradesh. Farmers are cultivating agriculture crops throughout rotation and consider poplar tree as ensured wealth of their future needs. The spacing for poplar plantation in generally kept 5 x 4 m or 5 x 5 m which allows tractor ploughing and other cultivation operation without any difficulty. The agriculture crops which are generally grown as an intercrop with poplar plantation are sugarcane, wheat, potato, gram, mustard, pea, soyabean, lentil, sorghum, maize, zinger, turmeric and vegetable crops like tomato, chillies, raddish etc. Considering the fast rate of growth, ease of establishment, easy marketing and multiferous uses. Poplar have been grown under various systems viz. agri-silviculture, agri-silvi-horticulture etc.

Studies on the economics of poplar plantation grown by Forest Department of Govt. land and by cultivators in their own farms were conducted at Forest Research Institute, Dehra Dun (Mathur and Sharma, 1983). The annual returns were discounted at 12, 15, 20 and 25 per cent. The net present value (NPV) per hectare in case of poplar plantation with and without agriculture in the forest land and on farmers land with agriculture at 8, 10 and 12 year rotation was calculated. The net present value (NPV) and benefit/cost (B/C) ratio was found maximum i.i. Rs. 11,046 and 3.22 respectively at 12 per cent interest with 8 years rotation in case of poplar plantation combined with agriculture on farmland as compared to Rs. 7,235 and 2.15 and Rs. 3,208 and 1.51 obtained in case of poplar plantation with agriculture on forest land and poplar plantation without agriculture in forest land, respectively. It was concluded that cultivation of agriculture crop with poplar at 8 years rotation ensure high economic returns.

Table 3

Influence of poplar tree line on the growth and yield of wheat crop

Distance from tree line	Shoot No/m²	Height wheat plants (cm)	Average ear length (cm)	Grain No/kg	Wheat grain yield (q/ha)
Below 4 m	231	78.14	8.76	26241	24.53
4 m to 8 m	200	75.63	9.03	26658	10.07
8 m to 25 m	247	82.53	9.42	26623	20.91
Above 15 m (Control)	237	75.10	9.31	27201	19.93

Growth and yield of wheat crop as influenced by single row bund plantation of *Populus deltoides* 'G-3' grown on southern aspect of the field in east-west direction were investigated (Sharma and Singh, 1992). Results indicate that wheat grain yield and other crop parameters have shown no significant difference in the sample plots laid out near tree line and plots laid out at farthest distance (control). However, some improvements in crop yield 10.63 kg was found in a zone of 15 m from tree line (Table 3).

Table 4

Total returns from poplar trees

Diameter class	No. of trees (cm)	Value of trees (Rs.)
21 to 22.30	3	450.00
24.30 to 28.20	5	1,750.00
29.00 and above	13	6,500.00
Total	21	8,700.00

The total income from 21 trees worked out to be Rs. 8,700 at 6 years age and Rs. 1,450 per year (Table 4).

SUMMARY

Agroforestry and associated outputs expected from practicing in different forms on farmlands are discussed. Traditional practices and sustainable considerations are based on improvement in technologies. Research results of some studies have been found beneficial in increasing productivity per unit area. Various species specific agroforestry models developed have been found economically viable propositions for land users.

खेती करने की प्रणालियों में कृषिवानिकी

के०के० शर्मा

सारांश

प्रस्तुत निबन्ध में कृषिवानिकी और विभिन्न कृषिभूमियों के लिए प्रत्याशित निवेशों का विवेचन किया गया है । पारम्परिक व्यवहार और चलाई जा सकने वाली धारणाओं को प्रौद्योगिकियों में हुए परिष्कारों पर आधारित किया गया है । विभिन्न अध्ययनों में मिले कुछ परिणाम क्षेत्र की प्रति इकाई उत्पादकता बढ़ाने के लिए लाभप्रद पाए गए हैं । विविध वृक्ष जातियों वाले विशिष्ट कुछ कृषिवानिकी प्रतिदर्श आर्थिक दृष्टि से भी लाभकारी संभावना पाए गए हैं ।

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FARM FORESTRY IN NORTH-WEST INDIA - A CASE STUDY

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Introduction

Trees did not form an important component of the farming systems in the North-West region of India in the past. Production systems in these alluvial plains, consisting of the Punjab, Haryana and Western U.P., and known as the "green revolution" belt of India, were exclusively geared to crop and livestock interaction. That farmers use their lands basically for crop production and would therefore plant only a few trees in homesteads or farm boundaries was the belief under which the tree planting programme in India, called farm forestry, was launched in the late 1970s. Farm forestry targets were kept modest and attention was focused more on planting by government on village lands. However, the results were totally unanticipated, and *Eucalyptus* hybrid cultivation by private households in this region surpassed all calculations. In U.P. during 1979-84 the target for farm forestry was overachieved by 3000% (Anon., 1985). In Haryana the area under trees on farms grew at a rate of 53% per annum between 1975 and 1984 (Anon., 1988). Indeed in Punjab, Haryana, Western Uttar Pradesh and Gujarat Farmers' enthusiasm for raising *Eucalyptus* on crop lands, even on irrigated lands, in the period 1980-85 took every one, the donor agencies and State Governments, by surprise. The anticipated high price of poles lured many farmers into producing *Eucalyptus* for sale, as it was perceived to bring higher returns than annual crops (Anon. 1986, 1988).

However, the programme achieved spectacular success only in regions characterised by commercial and monetised agriculture. The picture was radically different in subsistence oriented Eastern States like Orissa, Bihar, and Madhya Pradesh where farmers remained comparatively indifferent to private tree planting, despite the fact that rainfall and soil conditions are more favourable to trees in the east rather than in the semi-arid West and North India. And lastly, there is evidence to show that farmers enthusiasm to plant *Eucalyptus* declined after 1986 in North-West India, as the tree failed to generate the kind of returns farmers were expecting.

This paper, based on a field survey of six villages in U.P., examines the following issues relating to trees planted by the farmers in the last ten years :

1. Where were these trees planted and with what motivation? To what extent the original objectives of these farmers have been achieved?

2. Why did some farmers plant trees, and other did not? How do the planters differ from the category of non-planters in socio-economic characteristics?

3. For different categories of farmers how did tree plantation relate to

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availability of land, capital and labour, and to wider issues of agrarian dynamism, commercialisation, reinvestment of surplus, tenure, and diversification of rural economy?

4. Has there been any significant change in the last five years in the response of farmers to trees, due to their experience in the first ten years, specially with production and marketing of their produce? If so, with what consequence?

5. What price did the farmers get by selling their trees, and how did the profit from trees compare with other agricultural crops?

6. What marketing opportunities do exist for farm forestry products, how is wood transmitted from the place of production to the point of consumption, who are the intermediaries and what are their functions? How has demand and prices changed in the last five years, and what are the apparent constraints in the flow of tree products?

Methodology

The six villages were chosen from three Districts of U.P., Muzaffarnagar, Nainital (plains) and Allahabad. The first two districts represent the "green revolution" belt of U.P., whereas Allahabad represents the low productivity region of South-East U.P. Data were collected during 1989-90 in two stages. First, a complete village census listed the land owned by each family, caste and the number of trees owned or planted by them on farm lands, as well as homestead lands in the last eight years. The data showed that more than 50% of the total trees in the four villages of Western U.P. were planted by a few non-resident owners, many of whom had substantial business interests and had even bought land with the idea of making windfall profits from the growing of *Eucalyptus*. Since they can hardly be called farmers, we excluded them from the population from which sample was drawn for the second stage. Information was collected on land owned, number of working population in the family, agricultural practices used, non-agricultural incomes, caste, proportion of produce sold, economics, and marketing etc. from the cases in the sample, in all 207. In addition to the six villages, seven wood markets were surveyed to study the flow and price formation of farm *Eucalyptus*.

Regional Variation

The village census of trees indicated that there were in all 1667 households in the six villages, out of which them 321 got classified as planters. This percentage was lower for the Allahabad villages compared with the West U.P. villages, but the more significant difference was in the number of trees planted. High incidence of tree planting was primarily correlated with the degree of land productivity, surplus generated and commercialisation in the villages, as shown in Table 1.

The data on agricultural indicators in Table 1 show that the villages in Allahabad were poorer, with low irrigation, low productivity, and low surpluses to sell. The Allahabad villages were growing food crops mainly for subsistence. The dry soils of Deoghat had problem of moisture retention too, hence both crops and trees could not be grown on the same field. This constrained them from investing their land and capital in a long gestation crop, and therefore one finds that the number of families planting trees, as also the number of trees planted by

Table 1

Basic Data on villages and trees

Indices	Allahabad		Muzaffarnagar		Nainital	
	Deoghat	Alipur	Chaukra	Jhat	Hajeera	Bagwala
1. % land irrigated	0	66	95	93	85	93
2. Intensity of cultivation	106	133	177	231	168	194
3. Agr. Assets in Rs/ha	1413	4696	7478	9594	6404	7746
4. Fertiliser in Rs/ha	1	612	1140	1933	1406	1477
5. Production in Rs/ha	3191	7019	11049	17425	15640	18445
6. Production of area under food crops	98	89	58	51	64	49
7. % produce marketed	45	26	70	75	66	82
8. Payment to hired labour in Rs per ha	84	868	846	1829	1343	3204
9. % of farmers hiring labour	10	31	30	56	51	88
10. Daily wage rate in Rs during peak season	10-12	5-10	20-25	25-30	20-25	25-35
11. % share of large farmers[(a)] in Total landowners	23	9	26	38	34	62
12. % share of land of large farmers in total land	59	34	59	78	93	84
13. % of households planting trees[(b)]	6	11	19	20	32	37
14. Share of *Eucalyptus* + poplar	44%	66%	97%	98%	98%	97%
15. Trees						
Per household	17	23	252	265	274	362
Per planter	87	86	675	867	530	696

(Rows 1 to 9 are based on sample data, and the rest on census data)
(a) defined as owning more than 2.5 ha, (b) defined as planting or owning more than 50 trees.

them was significantly lower when compared with the commercialised villages of Western U.P. On the other hand, the four villages in Western U.P. had sufficient surplus and thus more risk-bearing capacity, had a long experience of growing cash crops like sugarcane and potato, and therefore had more confidence in innovating with another cash crop like *Eucalyptus*.

In all the four Western U.P. villages fodder is grown as a crop and cattle is generally stall-fed. As there is a crop 12 months in a year on the fields cattle is always herded, and protection to young seedlings from trampling by cattle is not a problem. On the other hand, Deoghat, and to a lesser degree Alipurjeeta, has long fallow periods, when cattle was let loose to browse the stubble in the field. This increased protection problems for trees.

Unlike seasonal crops trees, even the fast growing ones, take at least 6 to 10 years to mature. A long gestation period delays benefits and reduces a family's income from land in the intervening period. Therefore the landowner requires supplementary source of income or support, to tide him over the period when trees are not generating income. A tree like *Eucalyptus* gives income only in lumps, unlike plantation crops or fruit trees which give annual returns after the gestation period. Thus, the *Eucalyptus* farmer needs support during the years of "no income" throughout the period trees remain on farm.

Therefore tree planting for production of wood for sale should be viewed as a long gestation capital investment with recurrent costs, but no recurrent output, till trees matured. Such an investment is therefore likely to be undertaken by farmers and in regions which generate marketed surplus, where there has been a long tradition of growing crops for the markets, where other forms of capital investment in land, like installing tubewell or buying farm machinery, is common, and where profits from land are ploughed back into agriculture.

Large and small farmers

A literature review of tree planting across several continents concluded that small farmers produce for subsistence, whereas large farmers produce for market; hence small farmers are constrained from growing trees as cash crops (Anon. 1986). Ellis (1988) and Fafchamps (1992) hold that small farmers, because of considerations of family security, allocate a higher proportion of their land to subsistence food crops. The present field study did not support any of the above views. Small farmers in the studied villages followed a cropping pattern similar to that of large farmers in the same village, and used as much chemical fertiliser as large farmers. Despite this, there was distinct difference between the two class of farmers, as regards tree adoption.

As compared to 52 per cent of the large farmers (those owning more than 2.5 ha), only 17 per cent of the small farmers (owning between 0.5 and 2.5 ha), and 5 per cent of the tiny farmers (with less than 0.5 ha) planted trees. Small farmers were 40 per cent of the total number of households, owned 34 per cent of the land, but their share in trees was only 21 per cent. Among both large and small farmers, more trees were planted by upper-caste households. The share of lower castes in population, land, in the number of planters, and number of trees was 63, 40, 35 and 24 per cent respectively.

Within the category of planters, woodlot planters, although fewer in number, had several times more land, assets and non-agricultural incomes than other planters, and even more when compared with non-planters. Woodlot planters from the small farmers category also possessed substantial assets as compared to other small farmers, and even higher than the assets of non-planting large farmers. On the whole, one can conclude that land holding, asset position, ownership of grove lands, and the extent of diversification of sources of household incomes were positively correlated with levels of tree planting, especially for woodlot planting.

What most small farmers lacked was sufficient surplus and alternative incomes, which would enable them to tide over the period in which trees yielded no income. With MVs, small farmers could gradually increase the area, gain confidence, and reinvest the profits. As eucalypts took six years to mature, the production and financial results, even on the fields of large farmers, were not available to provide a 'demonstration' effect. The perception of the degree of risk involved was therefore much higher for a small farmer entirely dependent on land, especially in a region of fertile soils where annual crops offered a stable income. The distinction is perhaps better understood not in terms of subsistence vs. cash crops, but as short-duration vs. long-duration crops.

As regards the involvement of small farmers in cash crops, Bharadwaj (1985), Nadkarni (1980), Hill (1982) and Harriss (1984) conclude from evidence that those small farmers who are compulsively involved in markets tend to devote a higher proportion of their area to cash crops. In fact, some (Arnold *et al.*, 1987) hold that, as farm size declines, the production objective may change from growing food to generation of income with which small farmers buy food, and that the growth of agroforestry is often a response to this change in production objectives. Trees may also be planted by small farmers due to lack of credit for capital intensive crops. A World Bank study (Anon., 1986) found that small farmers in Kenya were short of both capital and labour needed for more intensive crops like coffee, and grew trees like *Eucalyptus* and wattle, which enabled them to commit a substantial part of their labour to off-farm employment. Our data, although from only one fertile region of India, do not support these conclusions. Trees, where planted, were not a consequence of declining farm size or shortage of capital, but a result of surplus generation from farm and off-farm occupations. However, shortages of family supervision were an important consideration, which is discussed in section VI. Thus, rather than tree growing is associated with peasants' subsistence and distress strategies, as Arnold and the World Bank study have argued, this case study shows that tree planting can be the outcome of a profit miximising strategy by surplus farmers.

Compelling factors in changing the land-use

The surplus vs. subsistence region, and the large vs. small farmer arguments that have been advanced in section III and IV explain why only some farmers in progressive regions were able to invest in a long gestation crop; but what compelled them to change their land-use in favour of a crop unknown to that area? This needs to be seen partly in the context of changes in factor and output markets in the region brought about by MVs, and partly in a local context of crop preferences. Three specific arguments have been given; the worsening terms of trade, the changes in sugarcane profitability, and labour and farm management problems.

There is sufficient evidence to suggest that the terms of trade have not been favourable to agriculture after 1974-75. This problem would be more acute in commercialised as against subsistence regions, and would make farmers in the former region more receptive to a new crop promising better returns with lower investment. The data on recent trends are not available, which could have linked terms of trade with de-adoption, and hence this argument has been only briefly touched upon in the thesis.

During the field work, many farmers in Western U.P. explained their adoption of *Eucalyptus* in terms of the low price and rising risks in the cultivation of the main cash crop of the region. The sugarcane price stabilised later, and returns from sugarcane improved. According to farmers, whereas the price of sugarcane had improved from Rs. 240 to 400 a ton in the last five years, that of *Eucalyptus* had declined from Rs. 400 to 360 a ton in the same period. Besides, *Eucalyptus* took six years to give income as against just a year for sugarcane. Data collected on this issue confirmed farmers' views, although admittedly more rigorous treatment is needed to compare profitability, risk and income variance, both for *Eucalyptus* and sugarcane, before and after 1985.

Labour and supervision issues

The third argument to explain the change in land-use is embedded in the farm management problems, increasingly faced by absentee and large land-owners since the beginning of the last decade.

The introduction of modern crop varieties and increase in agricultural production brought new problems of labour control mechanisms for the farmers. First, in Western U.P., wages were high and unemployment was low. As the demand for labour rose, transactions costs went up. Second, intensive agriculture demanded equally intensive supervision, which tied farmers to the land. And last, as productivity rose and tenants became more assertive, it became risky for absentee land-owners to do outright leasing of lands. In this context the planting of *Eucalyptus* appeared to them a very attractive proposition, economically and socially, as it promised to improve profitability, minimise the danger of losing control over land, and at the sametime cut down on their supervision time, as *Eucalyptus* required only one-fifth of labour for annual crops, and also required little labour or supervision between planting and harvesting. Tree output was easier to quantify than crop output, which further reduced the need for intensive supervision at the time of harvest.

Only a quarter of the planters invested in woodlot plantations, with implications for saving in labour costs, but the share of woodlot trees in the total was more than 60 per cent. A very large number of trees were planted - often more than 10,000 - by a small number of non-resident planters in Western U.P. who had difficulty in supervising their farms, as commuting to the village on a daily basis for supervising agricultural operations would have increased costs of raising annual crops substantially. As regards the resident woodlot planters, data showed that they generally had a fewer number of males available for supervising agricultural work in relation to the land owned, and thus faced problems in managing their farms efficiently. Thus, although most farmers started adoption with boundary plantings, most trees came up in woodlots planted by supervision-constrained households.

On the other hand, large land-owners in Eastern U.P., with cheaper labour and docile tenants, had less compulsion to change their cropping pattern, or leasing habits in favour of a labour extensive crop. The non-resident farmers in these villages preferred leasing out on a cash rent or crop-sharing basis (Saxena, 1992).

Leasing out was prevalent in Western U.P. villages too. Labour intensive crops like paddy and potato were being cultivated with crop sharing arrangements with tenants, who supplied family labour and got less than one-fourth of the crop, whereas labour extensive crops like *Eucalyptus* were being grown with hired labour under personal supervision. Thus, the technical requirements of a crop were influencing contractual arrangements. Bardhan had argued (1979) that labour-intensive technical change is likely to result in a higher incidence of tenancy. Our data support this, as in none of the cases growing of *Eucalyptus* was done with tenanted arrangement. Thus, one could conclude that labour extensive crops encourage self-cultivation.

Thus on the whole, the *Eucalyptus* adopting region seems to be characterised by a relative agrarian dynamism, high rates of growth through modern seeds and commercial crops, and labour shortages. Clearly, both push and pull factors were operating on the farmers. The planting of *Eucalyptus* appeared to them a very attractive proposition in commercialised regions, as it promised to reduce their costs, improve profitability, and at the sametime cut down on their supervision time. The internal dynamics of this region matched very well with the attributes of *Eucalyptus*, which was projected as a very lucrative crop in the early 1980s. Experts were predicting extremely high returns of 100 to 200 per cent IRR from its cultivation. But for several reasons, these highly publicised returns were not achieved by the farmers . Instead of a S-curve of adoption what was witnessed in Western U.P. was an inverted V-curve, a fast rise in popularity followed by equally fast decline.

Production problems with *Eucalyptus*

The financial analysis has been done only for boundary plantings. First, the data on the cost of inputs for woodlot planting were not reliable. Second, most farmers (242 out of 290) had done boundary planting only, and hence it was the dominant form of planting. Third, woodlot planting involved greater uncertainty and risk, and appeared less profitable than boundary planting, and hence it was more important to explain the discontinuation of the relatively more profitable option of boundary planting.

Many farmers had planted *Eucalyptus* on farm bunds, hoping to get a good income after six years. They did not anticipate that trees would cause any loss of agricultural production. In reality, loss in crop production in Western U.P. after the third year was upto a quarter of the total crop, depending upon soil and water conditions, spacing and location of trees, and other factors. The value of crop losses ranged from two to eight times the total direct investment in raising trees, as the crop remained poor upto several metres from the tree line. These losses drastically reduced the profits farmers were expecting from the sale of trees. The average B-C ratio at 15 per cent discount rate would have been around nine without crop losses, but came down to about two when crop losses were taken into account. Although farmers were better off after planting *Eucalyptus,* as none suffered losses, yet the reduced profit margin was not perceived to be sufficiently high to cover risk of production and of fluctuating output prices. If the discount rate is increased to 50 per cent, which is the minimum rate at which money is borrowed internally in the villages, very few farmers made profits.

The field data also show that farmers made more profits by doing close planting than when they increased the distance between the plants, a conclusion which goes against the received wisdom on the subject. A number of studies on the glut of *Eucalyptus* in North India advised farmers to maximise value by increasing spacing (Chaturvedi 1989; Anon., 1990, 1990; 1990), but our study shows that this advice would have been correct only if farmers could sell larger trees at a higher rate per ton. As Chapter 9 of the thesis shows, most trees with a bigger girth got sold as fuelwood, hence farmers were better off in their strategy of maximising biomass by following close spacing.

Problems in marketing farm *Eucalyptus*

Due to production problems and a short rotation, *Eucalyptus* grown by farmers remained thin, and had little use as timber, which required trees of bigger dimensions and higher density. Even when some trees reached timber dimensions, they were generally not used as timber due to the perceived diseconomies in bulking and grading. The output was suitable for pulping, but paper mills, based on wood, are supplied subsidised wood from the State Forest Department. Although lately the mills have started collecting *Eucalyptus* from the farmers too, there are organisation, informational, and locational problems in buying wood from scattered farmers and transporting it over a long distance. The *Eucalyptus* crop from farms was initially sought to be used as poles for scaffolding. But the market for poles was not able to absorb the substantial increase in supplies, and the pole prices plummeted. Ultimately, much of *Eucalyptus* wood is now being sold as fuelwood, at less than the expected price, for use in brick kilns, small establishments, and households.

Farmers rarely bring their produce to the towns, rather they wait for the buyers to come to them. In cases where the buyer - brick kiln or the paper mill - was located nearby, farmers had delivered wood bearing the risk of being harassed by government officials. Farmers' awareness about buyers, the prevailing market price, and government rules is generally weak. However, the hypothesis regarding small farmers getting a lower price for similar product could not be substantiated.

There are several reasons why farm output of *Eucalyptus* was consumed within the local economy only. First, as crop production is in private sector alone, government's function is promotional, and it has taken several steps to improve the marketing infrastructure for annual crops. But trees exist on forest lands too, and hence government staff is more concerned with regulatory duties of preventing theft from forest lands, rather then with helping farmers to market their produce. This has led to legal restrictions on the transport of wood, which act against the interests of producers, as these rigid laws act as a barrier between the producer and the market, and bring uncertainty in the operation of sale transactions. Second, traders dealing in farm *Eucalyptus* had little access to bank capital forcing them to seek its quick disposal. And finally, as *Eucalyptus* was low value wood, expenses on grading, bulking, storage and transport of farm *Eucalyptus*, were five to twenty times more than similar expenses on other species per unit price realised. For these reasons, farm *Eucalyptus* got sold locally to the buyers without much value added. The number of intermediaries between the producers and consumers was not high - often two or less than two - and their margins too did not appear excessive. In areas of *Eucalyptus* concentration, the price of both poles and fuelwood fell, presumably due to heavy arrivals of *Eucalyptus* in the market. Due to these constraints, the perception about

Eucalyptus changed from being a highly profitable crop to a risky crop with low and uncertain yields, and low and declining output prices. Many farmers therefore removed the coppice roots and went back to annual crops. No farmer did new planting after the experience of sale of *Eucalyptus*.

Future trends

Many cash crops follow a cyclic pattern of supply. Initially small supplies come to the market, which are sold at a handsome profit. This raises expectations, and farmers respond by increasing the area to the crop. This leads to increased supplies, a decline in prices, and consequently reduction in area. And thus the cycle continues. With regard to *Eucalyptus*, its production in Western U.P. is at a stage when new uses of *Eucalyptus* have been found, and it has started substituting for coal and other wood species. But the process took time, about four years, and by that time the supply of *Eucalyptus* in the markets started declining, as farmers had stopped growing the tree some four years back. So far the behaviour of supply and prices seems to support the Cobweb Theory. When the markets were last visited (October 1991), prices had started rising again. Whether this would tempt farmers to plant *Eucalyptus* again, and on what scale, is difficult to say. Farmers no longer hold the old expectations that *Eucalyptus* would not cause any loss to crop production, would grow to timber dimensions in six years, and each tree, would fetch a price of Rs. 100. Continuous research made MVs more user-friendly, more pest-proof, and they yielded more even with low inputs. With *Eucalyptus* too, technical issues seem to be holding the key to its future prospects.

SUMMARY

The six villages each from Muzaffarnagar, Nainital and Allahabad were studied and results are presented in detail.

उत्तर-पश्चिमी भारत में क्षेत्र वानिकी - एक विशिष्ट अध्ययन

एन०सी० सक्सेना

सारांश

मुजफ़्फ़रनगर, नैनीताल और इलाहाबाद प्रत्येक से दो-दो लेकर छह गांवों का अध्ययन किया गया और उससे मिले परिणाम विस्तार से इसमें प्रस्तुत किए गए हैं ।

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DYNAMICS OF GROWTH IN SOME AGROFORESTRY TREE SPECIES UNDER SOUTH SAURASHTRA REGION OF GUJARAT

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Introduction

Gujarat State is having barely 10 per cent tree cover with respect to forest, of its geographical areas. Even out of this 10 per cent of area, half of it, is commercially productive and half of the area is totally unproductive (mainly in Saurashtra, Kutch and North Gujarat regions). Saurashtra peninsula being a semi-arid zone, supports only a scrub of vegetative growth and mostly grasses and some fuelwood tree species (Anon., 1984).

In an agroforestry system, selection of suitable tree species is utmost important with respect to growth rate and survival. The dynamics of growth of different tree species is one of the main deciding factors, for crop rotation period. The fast growing tree species can have a shorter period of rotation than the slower growing ones. Information on behaviour of forest tree species with respect to growth and development is very scanty. This requires studies on growth under field conditions on certain identified tree species.

Under the climatic and edaphic conditions of Saurashtra region, the investigation on growth pattern of tree species was not undertaken earlier. The present study is the first of its kind on the tree species, which are multi-purposes. The importance of the growth pattern of any tree species need not to be over emphasized as without having knowledge on this vital aspect, the agroforestry system remains incomplete. It will not be possible to plan project without having basic information on growth.

The present research aimed to conduct comprehensive studies and to generate information on dynamics of growth in 10 commonly growing multipurpose tree species of agroforestry viz., *Albizia lebbek* (Siris), *Azadirachta indica* (Neem), *Cassia fistula* (Amaltas), *Casuarina equisetifolia* (Casuarina), *Cordia dichotoma* (Cordia), *Eucalyptus* hybrid (Eucalyptus), *Melia azedarach* (Persian lilac), *Pithecellobium dulce* (Manila tamarind), *Syzygium cumini* (Jamun) and *Tamarindus indica* (Tamarind).

Materials and Methods

The experiment was conducted during July, 1991 to January, 1994 at Department of Horticulture, College of Agriculture, Gujarat Agricultural University, Junagadh Campus, Junagadh. The experiment was conducted in randomised block design with three replications. Six months old saplings of each tree species were planted during July, 1991. All cultural operations were adopted with respect to plant protection, irrigation, weeding, digging, stalking and mounding as and when required. Fertilizers in form of area, single superphosphate and muriate of potash in equal quantity of 50 g/plant were applied three months after planting. Thereafter manuring was not done.

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The cent per cent population was maintained by immediate gap filling. One alternate plant in each treatment, selected randomly from each replication, was cut at ground level at 6 months interval and used for recording observations on height, girth, number of leaves and leaf area. The number of leaves and leaf area were recorded for all the tree species except *Casuarina*. Leaf area of sample leaf was measured by digital leaf area meter and total leaf area per plant was calculated by multiplying leaf area of a sample leaf with total number of leaves per plant (Tewari *et al.*, 1987). In case of *Casuarina*, total photosynthetic area was recorded by taking needle surface area of 1 g sample of dry needle and multiplying it with total dry weight of needle (Van Den, 1968). The data recorded were statistically analysed.

Results and Discussions

Survival percentage : The maximum survival percentage (98.72%) was recorded in Neem and Tamarind which was at per with *Casuarina*, Persian lilac, Manila tamarind, Siris, *Cordia*, Jamun and Amaltas. The minimum survival percentage (78.0%) was recorded in *Eucalyptus*. Thus, all the tree species except *Eucalyptus* established excellently (Table 1). Higher survival percentage was expected because planting coisides with monsoon having high atmosphere humidity. Moreover, better care during planting further favours to higher survival. Higher survival percentage in Neem, *Cordia* and Manila tamarind and lower survival percentage in *Eucalyptus* are in accordance with the results of experiment conducted under Arnej (Gujarat) conditions (Anon., 1992 b).

Height : The plant height of different tree species differed significantly at all the observations (Table 1). At six months after planting, *Eucalyptus* had the maximum plant height which was at par with Persian lilac and both were significantly superior to rest of the tree species at this stage of growth. Siris attained the maximum plant height from 12 to 30 months age except at 18 months age when the maximum plant height was noted in Persian lilac. However, both these tree species were statistically at par at 18, 24 and 30 months age. At 12 months age, Siris followed by Persian lilac. Both these tree species were also at par with *Eucalyptus* and *Casuarina* at 18, 24 and 30 months age. Neem and Amaltas (in later phase of growth after 24 months age) had higher plant height than remaining all other tree species. Manila tamarind and *Cordia* had medium while Jamun and Tamarind had less plant height throughout the experiment.

Variability in growth might be due to differences in genetic make up of different tree species which exhibits in plants particularly raised by seeds. The higher growth in terms of height in Siris and Persian lilac may be due to their inherent rapidly growing habit. Vigorous height growth in Siris and Persian lilac was also recorded compared to that of *Cordia*, Amaltas, Jamun and Tamarind under Western Himalayan conditions (Toky and Khosla, 1984). Medium

Table 1

Survival percentage, height (m) and girth (cm) of different tree species at six months interval under field conditions

Month/species	Survival percentage	Height (m)					Girth (cm)				
		6	12	18	24	30	6	12	18	24	30
Albizia lebbek	96.15 (78.65)	1.25	4.12	5.80	7.37	9.10	6.17	25.33	28.00	31.00	39.67
Azadirachta indica	98.72 (86.22)	1.30	3.25	4.52	5.70	6.80	4.50	16.67	23.33	29.33	36.00
Cassia fistula	92.31 (74.21)	0.24	1.33	2.33	5.29	6.05	2.33	10.17	18.67	26.00	34.00
Casuarina equisetifolia	97.44 (84.62)	1.20	3.36	5.51	6.40	7.60	6.17	17.33	20.00	26.67	29.00
Cordia dichotoma	96.15 (78.65)	0.90	2.73	4.07	4.33	4.70	7.67	20.33	52.00	55.67	63.67
Eucalyptus hybrid	78.20 (62.16)	1.87	2.65	5.27	6.03	7.30	6.50	12.67	18.67	31.33	37.00
Melia azedarach	97.43 (82.44)	1.77	3.83	6.13	6.99	8.80	10.00	20.83	37.33	45.00	60.00
Pithecellobium dulce	97.43 (82.44)	0.90	2.68	4.40	4.83	5.50	3.57	11.33	24.33	30.00	40.00
Syzygium cumini	94.87 (77.06)	0.74	1.33	1.98	2.53	3.10	4.33	6.50	12.33	9.33	25.00
Tamarindus indica	98.72 (86.22)	0.71	1.57	2.17	3.07	3.50	2.00	6.83	15.67	18.33	23.33
S. Em.±	2.50	0.06	0.12	0.53	0.34	0.28	0.37	0.87	1.61	1.17	0.77
C.D. at 5%	7.43	0.19	0.36	1.56	1.00	0.83	1.10	2.59	4.79	3.48	2.30

(Figures in the parenthesis indicate the transformed values) height growth in *Casuarina* and *Eucalyptus* are in confirmity with the earlier observations by Nath *et al.* (1991) and Das (1981). Higher height was also observed in Siris followed by Neem under S.K. Nagar (Gujarat) conditions (Anon., 1992 b).

Stem girth : The data on stem girth of different tree species presented in Table 1 indicate significant differences at various intervals. At 6 months age, Persian lilac had significantly the highest stem girth followed by *Cordia* and Siris. At 12 months age, Siris ahad the thickest stem followed by Persian lilac which was at per with *Cordia.* From 18 to 30 months age, *Cordia* had significantly the highest stem girth followed by Persian lilac. Persian lilac was followed by Siris and Neem at 18, *Eucalyptus,* Neem and Amaltas at 24 and Manila tamarind, Siris, *Eucalyptus* and Amaltas at 30 months age. Thus, among the different tree species tried *Cordia* and Persian lilac had the thickest stem; Siris, Neem, Amaltas, *Casuarina, Eucalyptus* and Manila tamarind had medium thick stem while Jamun and Tamarind had thin stem.

The species sequence based on radial growth was quite different than based on height. These findings corroborate the findings of Toky and Khosla (1984). Higher girth was recorded in *Cordia* followed by Siris, confirm the results recorded under Arnej (Gujarat) conditions (Anon., 1992 a). Similar results were also obtained by Gupta *et al.* (1988) under Coimbatore (Tamil Nadu) conditions.

Number of leaves : The number of leaves per plant was differed significantly throughout the experimental period (Table 2). Manila tamarind had significantly the highest number of leaves consistently which was followed by Persian lilac at 6 months age and Tamarind from 12 to 30 months age. The leaf number in Tamarind at 12, 18 and 30 months age was at par with Persian lilac. The number of leaves per plant was lower in Siris, Amaltas and Jamun throughout the experiment. Whereas, it was at middle range in Neem, *Cordia* and *Eucalyptus*.

The reduction in number of leaves retained per plant was also observed in different tree species except *Eucalyptus*, Persian lilac and Jamun. The peak for number of leaves per plant was noted in Siris at 12 and 24, Neem at 24, Amaltas at 6 and 18, *Cordia* at 12 and in Manila tamarind and Tamarind at 18 months age.

The number of leaves depends on the number of nodes and length of internodes in tree species. The tree species having higher number of nodes with short internodes have higher number of leaves and the tree species having less nodes with longer internodes have less number of leaves. The reduction in number of leaves show the deciduous or partial deciduous nature of the tree species.

Total leaf area : The total leaf area per plant in different tree species and total photosynthetic area in *Casuarina* recorded at six months interval differed significantly (Table 2). Significantly highest total leaf area was recorded in Persian lilac throughout the experimental period followed by *Eucalyptus* at 6 and Siris at 12 and 18 months age. The tree species viz., *Cordia, Eucalyptus* and *Casuarina* at 12 and Siris and Neem at 18 Months age were statistically at par. *Casuarina, Eucalyptus,* Manila tamarind, Jamun and Tamarind had lower total leaf area throughout the experiment as compared to other tree species. The total area was abruptly increased in Siris at 12 months age. Amaltas had higher total leaf area in later phase of

Table 2

Number of leaves and total leaf area (m^2) per plant in different tree species at various intervals under field conditions

Month/Species	Number of leaves/plant					Total leaf area (m^2/plant)				
	6	12	18	24	30	6	12	18	24	30
Albizia lebbek	47	461	287	629	476	1.030 (219)	46.29 (1004)	28.15 (980)	27.95 (445)	21.20 (445)
Azadirachta indica	34	1000	1160	3283	2960	0.320 (94)	26.29 (264)	27.22 (234)	53.56 (163)	48.30 (163)
Cassia fistula	15	22	419	419	593	0.200 (133)	0.300 (136)	13.08 (311)	27.45 (559)	33.20 (559)
Casuarina equisetifolia	0.10*	1.62*	0.72*	1.59*	1.63*	0.23** (68)	6.14** (38)	5.75** (62)	4.98** (31)	5.10** (31)
Cordia dichotoma	183	877	800	885	1010	1.63 (90)	9.95 (113)	11.30 (141)	8.40 (95)	9.60 (95)
Eucalyptus hybrid	268	662	1565	2000	2385	1.78 (66)	5.90 (89)	7.55 (49)	10.98 (55)	13.10 (55)
Melia azedarach	407	1323	2655	2337	4896	6.63 (163)	59.02 (446)	118.40 (446)	58.06 (174)	85.20 (174)
Pithecellobium dulce	625	5000	12166	9350	14736	0.47 (8)	5.55 (11)	13.14 (11)	7.11 (8)	11.20 (8)
Syzygium cumini	69	288	919	1250	1816	0.36 (45)	1.38 (48)	5.28 (58)	9.02 (72)	13.10 (72)
Tamarindus indica	162	1454	7300	4083	8160	0.16 (10)	2.09 (14)	13.80 (19)	5.10 (13)	10.20 (13)
S.Em.	12.41	92.77	389.81	115.40	355.59	0.11	1.57	8.01	0.81	1.35
C.D. at 5%	37.22	278.12	1169.00	345.41	1066.11	0.31	4.66	23.81	2.40	4.02

Figures in the parenthesis indicate leaf area (cm^2/leaf) and photosynthetic area (cm^2)/g) in case of *Casuarina*

* Dry weight of total photosynthetic branchlets kg/plant.

** Total photosynthetic area

growth after 24 months age.

Reduction in total leaf area was also observed in different tree species except Amaltas, *Eucalyptus* and Jamun. The total leaf area was declined in Siris at 18, 24 and 30; Neem at 30, *Casuarina* at 18 and 24; *Cordia*, Persian lillac, Manila tamarind and Tamarind at 24 months age.

The total leaf area is a function of number of leaves retained and their size. Since the number and size of leaves both were higher in Persian lilac, Neem and Amaltas (in later phase of growth), all these tree species had higher total leaf area. Whereas, in Manila tamarind, Tamarind and *Eucalyptus*, in spite of higher number of leaves, the total leaf area was less due to its small size leaves. The photosynthetic area in *Casuarina* which recorded on the basis of dry weight of photosynthetic branchlets was also less due to lower weight of photosynthetic branchlets (Table 2).

SUMMARY

Among the ten tree species tried in field conditions of South Saurashtra region of Gujarat at College of Agriculture, Gujarat Agricultural University, Junagadh, the survival percentage was higher in all the tree species except *Eucalyptus*. Siris and Persian lilac had higher plant height while the stem girth was higher in *Cordia* and Persian lilac. The number of leaves retained per plant was highest in Manila tamarind followed by Persian lilac. The total leaf area per plant was highest in Persian lilac followed by Siris and Neem.

गुजरात के दक्षिण सौराष्ट्र प्रदेश में कृषिवानिकी पेड़ों की कुछ प्रजातियों में वृद्धि की शक्ति

एन०एल० पटेल व एस०पी० सिंह

सारांश

गुजरात के दक्षिण सौराष्ट्र प्रदेश में गुजरात कृषि विश्वविद्यालय जुनागढ़ केन्द्र में स्थित कृषि महाविद्यालय के फार्म की परिस्थिति में परीक्षण की गई पेड़ों की दस प्रजातियों में से सफेदा के सिवाय सभी में जीवित रहने की मात्रा की प्रतिशतता अधिक पाई गई । सिरिस और बकैन मे अधिक ऊँचाई पाई गई । परन्तु थड़ की गोलाई लसुरा और बकैन में अधिक पाई गई । पेड़ पर पत्तियों की संख्या क्रमशः जंगल जलेबी और बकैन में अधिक पाई गई । पत्तियां का कुल विस्तार क्रमशः बकैन, सिरिस और नीम में अधिक पाया गया है ।

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TRIALS OF POPLAR CLONES IN HARYANA VILLAGE FARMS - EARLY EVALUATIONS

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Introduction

Poplars have been successfully incorporated in agroforestry plantations and have been extensively planted in farmlands in U.P., Haryana and Punjab after 1980 (Chaturvedi, 1992). Plains of Haryana with their fertile soil and high water table have been found to be quite favourable for raising poplar plantations. Poplars have found wide acceptability amongst the farming community for their fast rate of growth and phenological characters which make them convenient to raise in combination with agricultural crops. The incorporation of poplars in agroforestry in this region has led to the growth of plywood industry where there is little timber available from forests. The programme for research and introduction of poplars was started by the Forest Research Institute, Dehra Dun in 1958, with the first import of selected poplar clones from the United Kingdom. Subsequently more clones obtained from U.K., Turkey, Germany, France, Austria, Italy, Netherlands, U.S.A, Australia, etc. were tested and suitable ones introduced. The success of some of the exotic clones of poplars like IC, and I-488 led to more clonal trials and clones like G-3, G-48, and D-121, became quite popular with the Forest Department and the farmers of Northern India. In order to tap greater potential of poplars and to find replacement for today's clones there is a need to intensify the clonal trials and introduce newer clones into agroforestry systems. In order to maintain genetic diversity to insure against epidemic outbreaks of pests and diseases it has been suggested that 5% to 10% of the existing clones should be replaced by superior ones every year (Zsuffa, 1983). The Poplar Research Centre in the Social Forestry Division of F.R.I., Dehra Dun has taken several steps to introduce new clones of poplars, conduct the clonal trials and recommend the suitable ones for the farmers' fields. The activity got further impetus through the UNDP project which includes a component of extending material and methods for raising trees by farmers. Clonal trials of poplars have been laid in 5 villages of Yamunanagar District of Haryana. The early findings of these trials are presented here.

Materials and Methods

Five villages under Chhachhrauli Block of Yamunanagar District (Haryana) have been chosen by the F.R.I. for extension of agroforestry technology. The villages are - Nahartaharpur, Balauli, Urjani, Sherpur and Chuharpur khurd. Diesel and electric pump sets are the common mode of irrigation in these fields. A total of about 18000 ETPs

(Entire transplants) of 17 clones were distributed in February, 1994 among the farmers of these five villages on the basis of the individual land holdings and the initiative shown by the farmers. Farmers were given the technical knowhow for raising the plantation and its subsequent upkeep. For the research trials, each of the three villages, viz., Nahartaharpur, Balauli and Urjani constituted a randomized block under R.B.D. for row planting and block planting. Three progressive farmers, namely Sant Prakash Singh (Nahartaharpur), Manmohan Singh (Balauli) and Mehar Singh (Urjani) offered to participate in research trials. The planting was done in pits of 76 cm depth and 15 cm breadth prepared manually. The details of the line plantation and compact block plantation trials are as detailed below.

(a) *Line Plantation:* A total of 20 poplar clones were taken up for line plantation trials (Table 1). Ten ETPs of each clone were planted under each replication at a spacing of 3 m on farm bunds.

Most of these clones were selected on the basis of nursery trials conducted by the Poplar Research Centre earlier at FRI. Some clones were obtained from Silviculturist-Sal, Haldwani and WIMCO. G-3, G-48 and D-121 have long been established as superior clones and were included in the study as standards. As for S7C15, S7C8 and G-3 clones, these were taken from two sources viz., F.R.I. and WIMCO to compare the two sources for differences due to nursery practices or apprehension of mixing of some clones.

(b) *Compact Block Plantation* : Compact block plantation trial consisted of 10 poplar clones, planted at a spacing of 5m x 4m in the agricultural field (Table 2). 20 ETPs were planted in each replication.

Table 1

Poplar clones under line plantations

Treatment No.	Clone	Source
T1	6239	FRI, Dehra Dun
T2	9/54-9	—do—
T3	6408	—do—
T4	D-121	—do—
T5	3294	—do—
T6	2663	—do—
T7	S7C15	—do—
T8	G-3	—do—
T9	G-48	—do—
T10	St-74	—do—
T11	S7C8	—do—
T12	S7C20	—do—
T13	L-89	Silviculturist-Sal, Haldwani
T14	L-87	—do—
T15	L-88	—do—
T16	L-90	—do—
T17	S7C15	WIMCO Salehpur (Ambala)
T18	G-3	—do—
T19	S7C8	—do—
T20	St-67	—do—

Table 2

Clones of poplar under compact block planting

Treatment No.	Clone	Source
T1	D-121	Silviculturist-Sal, Haldwani
T2	G-48	—do—
T3	L-87	—do—
T4	L-88	—do—
T5	L-89	—do—
T6	L-90	—do—
T7	G-3	WIMCO Salehpur (Ambala)
T8	G-48	—do—
T9	S7C15	—do—
T10	St-67	—do—

The clone G-48 came from two sources, i.e. Silviculturist-Sal, U.P. Forest Department and WIMCO due to the reasons explained earlier.

Growth parameters, viz., height, collar diameter, diameter at breast height (dbh) and survival are being recorded periodically.

Results and Discussions

The present discussion is based on one year growth performance of these clones where are continuously monitored.

Line Plantations

(a) *Balauli* : The growth parameters, both at the start and after one year of the trial have been shown in Table 3. The highest growth in height and diameter has been put on by L-series clones, the clones L-89 and L-88 recording a total height of 9.32 m and 9.34 m and a dbh (diameter at breast height) of 86.59 cm and 85.68 cm respectively. S7C15 clone has also shown good height growth and excellent survival. There has been significant difference in height in case of same clone, viz., G-3 from different sources. This appears to be primarily due to the initial differences in height of the ETPs taken from different sources. The poor survival in cases of some of the clones can be ascribed to biotic interference, Nilgai being a perpetual menace in these areas. Proper care and maintenance are likely to be the other factors.

(b) *Nahartaharpur* : In case of Nahartaharpur the clone S7C15(W), St-67(W), G-3 from both sources) and St-67(W)

Table 3

Line Plantation Trial at Balauli: Average of Growth measurements.

Name of the Farmer - Manmohan Singh

Clone	At the start				After one year			
	Total ETPs	Height (m)	Collar Dia. (cm)	Dbh (cm)	No. Surviving	Height (m)	Collar Dia. (cm)	Dbh (cm)
6239	11	3.18	19.23	13.49	10	5.63	70.49	51.83
9/54-9	10	3.15	21.06	14.50	7	5.00	58.78	38.54
6408	11	2.21	19.11	11.77	11	4.90	57.94	43.10
D-121	11	2.40	20.28	13.39	6	3.56	39.59	25.57
3294	11	2.74	19.11	11.77	11	4.57	52.32	36.89
2663	10	2.76	17.66	10.75	8	3.38	36.48	25.13
S7C15	11	4.61	28.80	21.80	11	7.19	78.51	60.65
G-3	11	2.76	22.33	15.17	3	3.26	34.09	22.19
G-48	11	2.87	24.53	16.55	4	3.90	36.84	24.19
St-74	11	4.03	28.92	22.39	11	6.30	69.72	52.58
S7C8	11	3.01	18.11	12.37	9	6.71	67.57	54.12
S7C20	11	2.06	15.84	9.44	7	2.97	28.50	18.55
L-89	11	4.71	33.87	26.87	7	9.32	100.49	86.59
L-87	10	4.73	32.17	24.50	10	8.29	93.45	78.20
L-88	11	4.82	29.06	24.20	9	9.34	99.44	85.68
L-90	10	4.54	27.63	21.55	10	6.84	87.26	69.38
S7C15(W)	10	4.86	27.46	20.99	10	6.86	73.40	58.09
G-3(W)	10	4.95	25.03	20.49	10	6.72	59.30	48.23
S7C8(W)	10	3.90	21.63	15.48	10	6.59	70.10	54.31
St-67(W)	10	3.96	20.33	15.27	9	5.81	59.24	44.22

have shown excellent growth performances (Table 4). However, in contrast to Balauli the L-series clones have not survived at Nahartaharpur. This observation needs to be evaluated with reference to their performance at other villages. In case of the clones '6239' and 'L-89' the growth shown after one year has been less as compared to the initial parameters. It is due to the fact that the survival has been very poor in these cases and those surviving have been rather low in growth. The browsing by Nilgai and casualty of the bigger ETPs causing smaller average growth measurements than the initial ones could be the reasons for this.

(c) *Urjani* : The results are more or less on the same pattern as those of Nahartaharpur. The clone S7C15(W) has led all other clones in respect of height, dbh and survival (Table 5). The response of the farmers of Urjani in general has not been adequate regarding the care at the time of planting and thereafter. At Urjani too, like Nahartaharpur, L-series clones have shown poor survival.

Compact Block Plantation

The compact block plantation trials have been undertaken with a view to allow the farmers to practice the usual intercropping of agricultural crops except paddy. Table 6 and 7 reveal the growth data

Table 4

Line Plantation trial at Nahartaharpur: Average of growth parameters

Name of the Farmer - Sant Prakash Singh

Clone	At the start				After one year			
	Total ETPs	Height (m)	Collar Dia. (cm)	Dbh (cm)	No. Surviving	Height (m)	Collar Dia. (cm)	Dbh (cm)
6239	11	3.98	23.31	17.54	4	3.55	41.94	27.30
9/54-9	11	3.40	20.50	14.33	11	3.59	50.41	30.25
6408	11	2.70	20.34	14.36	11	4.80	62.00	47.07
D-121	11	2.39	20.20	12.42	11	5.14	58.94	43.75
3294	11	3.01	24.69	16.41	10	3.99	54.84	32.45
2663	11	3.52	21.57	16.13	10	5.71	43.53	33.83
S7C15	11	3.18	20.32	13.14	10	5.15	44.47	33.29
G-3	11	3.16	26.86	18.35	10	6.92	88.14	63.04
G-48	11	3.12	22.26	15.35	11	6.17	67.49	47.95
St-74	11	2.99	21.07	13.03	8	4.23	45.63	32.31
S7C8	11	3.00	16.05	11.69	9	4.65	45.80	34.80
S7C20	11	2.56	17.11	11.16	11	4.55	34.04	25.82
L-89	11	5.24	33.08	26.17	1	4.00	28.08	22.47
L-87	11	4.67	30.28	24.58	-	-	-	-
L-88	11	4.36	27.88	21.40	-	-	-	-
L-90	11	4.63	28.36	21.55	-	-	-	-
S7C15(W)	10	4.42	26.46	20.93	10	8.09	53.80	42.97
G-3(W)	11	3.83	23.17	17.60	10	8.63	50.02	39.11
S7C8(W)	10	4.26	25.37	19.49	9	7.66	75:77	56.38
St-67(W)	10	5.02	28.39	22.97	10	7.16	68.78	53.85

Table 5

Line Plantation trial at Urjani: Average of Growth parameter

Name of the Farmer - Mehar Singh

Clone	At the start				After one year			
	Total ETPs	Height (m)	Collar Dia. (cm)	Dbh (cm)	No. Surviving	Height (m)	Collar Dia. (cm)	Dbh (cm)
6239	11	4.28	26.34	19.40	6	5.52	63.98	42.56
9/54-9	11	3.53	24.62	16.50	8	4.26	45.62	28.92
6408	11	2.94	23.77	16.20	8	4.53	52.08	36.80
D-121	11	2.33	19.51	12.23	11	5.20	49.74	35.71
3294	11	3.18	20.52	15.98	4	3.35	38.24	24.16
2663	11	2.90	17.66	12.34	6	4.48	23.88	18.97
S7C15	11	3.07	22.52	15.40	11	4.68	41.29	30.79
G-3	11	3.96	24.99	19.22	8	5.36	41.22	34.74
G-48	11	2.79	24.80	16.03	7	5.65	50.96	34.41
St-74	11	2.82	20.45	14.54	6	4.78	32.74	24.07
S7C8	11	2.86	22.47	16.66	8	4.55	38.47	30.54
S7C20	11	2.45	19.59	13.56	10	5.39	42.53	34.27
L-89	11	4.95	29.10	24.63	-	-	-	-
L-87	11	3.80	23.26	19.44	-	-	-	-
L-88	11	4.36	27.52	22.93	-	-	-	-
L-90	11	4.85	30.22	24.25	-	-	-	-
S7C15(W)	10	4.13	23.25	17.91	10	8.30	94.21	77.29
G-3(W)	10	2.50	19.24	13.29	3	5.06	33.70	25.69
S7C8(W)	10	4.49	26.63	21.65	9	5.47	45.18	34.35
St-67(W)	10	4.32	26.74	21.33	10	7.06	53.11	43.06

at the beginning and after one year of the trial in respect of two villages, namely, Nahartaharpur and Urjani. In case of Nahartaharpur, the survival has been reasonably well barring L-89 and L-90 clones. The clones G-3(W), G-48(W) and S7C15(W) have come good both on survival and growth counts. Though survival is below 25% for L-90 clone, yet growth rate for those surviving has been excellent. This hints at specific requirements of L-90 clone for survival. The survival has been rather poor for Urjani village replication. The growth performance also has been low in this village. The clone G-48 from WIMCO source has shown slightly better growth performance as compared to ETPs availed from the Silviculturist-Sal, but the difference has not been significant.

In case of the 3rd replication of the compact block plantation trial at Balauli village, there has been no survivals. The concerned farmer, Shri Harbhajan Singh, much against the advice of the research institute, sowed paddy in the block and accumulated water over there which led to the weakening of the poplar plants at the base and their consequent downfall. Dithering over the site leading to delayed planting has been another reason for the undoing of his plantation.

Table 6

Block Plantation trial at Nahartaharpur : Average growth parameter

Name of the Farmer - Jagmohan Singh

Clone	At the start				After one year			
	Total ETPs	Height (m)	Collar Dia. (cm)	Dbh (cm)	No. Surviving	Height (m)	Collar Dia. (cm)	Dbh (cm)
D-121	10	4.2	28.54	22.26	9	5.98	74.36	54.23
G-48	18	4.1	28.12	21.43	9	7.06	79.59	60.61
L-87	20	3.9	24.89	18.46	14	6.66	74.79	57.16
L-88	20	4.4	29.28	23.64	15	5.99	59.23	45.89
L-89	18	4.1	26.65	20.31	6	6.86	70.77	55.64
L-90	18	4.2	30.38	23.94	4	7.75	93.06	69.19
G-3(W)	18	4.2	25.37	18.22	18	7.10	61.48	48.81
G-48(W)	19	4.5	26.52	20.70	19	7.45	84.00	63.38
S7C15(W)	18	4.4	26.32	21.38	16	7.61	88.13	65.39
St-67(W)	19	4.7	27.20	21.95	18	6.74	70.38	54.10

Table 7

Block Plantation trial at Urjani: Average growth parameters

Name of the Farmer - Mehar Singh

Clone	At the start				After one year			
	Total ETPs	Height (m)	Collar Dia. (cm)	Dbh (cm)	No. Surviving	Height (m)	Collar Dia. (cm)	Dbh (cm)
D-121	20	4.2	31.32	23.31	4	6.20	54.88	44.03
G-48	20	4.6	29.95	23.48	5	5.52	42.28	34.91
L-87	20	4.2	30.06	23.80	9	4.90	39.04	30.78
L-88	20	4.3	28.80	23.00	9	4.97	39.51	32.25
L-89	20	4.5	31.15	24.19	7	5.17	39.05	31.37
L-90	20	4.5	29.43	22.56	4	4.90	43.15	34.77
G-3(W)	20	4.6	24.84	17.10	13	5.36	39.65	31.29
G-48(W)	20	4.4	25.40	19.44	8	5.61	44.19	36.01
S7C15(W)	20	4.4	27.79	22.23	6	5.08	32.83	26.42
St-67(W)	20	3.9	28.86	22.20	13	5.25	40.80	33.33

The trials thus far have shown that the clones S7C15, St-67, G-3, and G-48 are performing very well in row plantation as well as compact block planting in agricultural fields. For row planting, clone S7C8 also has shown good performance. However, this clone needs to be tested in compact block plantation also as it had not been included in the current study for block planting. Clones of L-series have shown excellent growth performance in row planting in Balauli, and similar growth but poor survival in block planting at Nahartaharpur but generally the survival has been poor. This indicates that they have excellent potential for growth if proper care is taken in their upkeep. Conditions of waterlogging appear to be very injurious to their very survival. These clones need to be watched under optimum conditions of growth. The clones G-3 and G-48 have exhibited better performance in this area as compared to Jammu (Dutt and Jamwal, 1994). These clones together with D-121 are showing their versatility for varying regions of India and have performed well in nursery trials even on the semiarid Tiruchirapalli in South India (Rao *et al.*, 1993). The trials will have to be continued for full five years in order to assess their economic performance.

SUMMARY

20 clones in line plantation and 10 clones in compact block plantation trials have been laid out in the farmers agricultural fields at Yamunanagar (Haryana) by planting the ETPs of poplar clones under the agroforestry extension programme of UNDP project. Early findings indicate that the clones S7C15, St-67, G-3, and G-48 are good for line plantation as well as compact block plantings whereas for row planting the clone S7C8 also has shown good results. Clones L-88 and L-89 also appear to have good potential for growth in row planting but need more care and maintenance as compared to other clones. The results also prove that timely planting and proper care of the plantation are sine qua non for successful agroforestry plantations based on poplars.

हरियाणा के ग्राम खेतों में वन पिप्पल (पोपलर) कृन्तकों को लगाने के परीक्षण - प्रारम्भिक मूल्यांकन

पी० खन्ना, डी०सी० कर्णाटक व ए० चन्द्र

सारांश

संयुक्त राष्ट्र विकास परियोजना के कृषिवानिकी विस्तार कार्यक्रम के अन्तर्गत वन पिपल (पोपलर) कृन्तकों के ईटीपी (आर्थिक वृक्ष रोपवन) लगाने के लिए यमुनानगर (हरियाणा) के किसानों के खेतों में रेखीय रोपण में 20 कृन्तक और निविड खण्ड रोपण में 10 कृन्तक परीक्षणार्थ लगाए गए । प्रारम्भिक जांच से पता चलता है कि रेखीय रोपण और निविड खण्ड रोपण दोनों के लिए एस 7 सी 15, स्टे 67, जी-3 और जी-48 कृन्तक अच्छे रहेंगे जबकि पंक्ति रोपण के लिए एस7सी8 कृन्तक के लगाने पर अच्छे परिणाम मिले हैं । एल-88 और एल-89 कृन्तकों को पंक्तियों में लगाने पर अच्छी संभावनाएँ लगती हैं परन्तु अन्य कृन्तकों की तुलना में इनकी अधिक देखभाल और रखरखाव की जरूरत प्रतीत होती है । ये परिणाम यह भी सिद्ध करते हैं कि समय पर रोपना और रोपण की समुचित देखभाल करना वन पिप्पल (पोपलर) पर आधारित कृषि वानिकी रोपवनों की सफलता के लिए परम अनिवार्य बातें हैं ।

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ECONOMICS OF FARM FORESTRY IN HARYANA - AN ECONOMICALLY VIABLE AND ECOLOGICALLY SUSTAINABLE SYSTEM

HARMINDER SODHI* AND M.Y. ANSARI**

Introduction

In the light of the serious problem of ever increasing ecological imbalance due to destruction of forests, the implementation of the concept and philosophy of "multiple use of land with multipurpose tree species" has become immensely important. Farm forestry, which is multiple use form of land management, involves deliberate retention, introduction or mixture of trees in crop production, with a view to benefiting from the resultant ecological and economic interaction.

Although so many tree species are being raised in Haryana in under farm forestry, Poplar planting has been selected for an in-depth study here in view of its important contribution towards rural economy viz; employment in different operation of growing, availability of fuelwood through pruning and serve as a windbreak. Besides this poplar tree with straight and cylindrical bole, moderate conical crown, mostly deciduous during winter months, combines well with the inter - cultivation of agricultural crops. Poplar planting helps to protect crops from the scorching sun, dessicating effects of wind and also to control soil erosion, making poplar currently the most popular tree species to be adopted for farm forestry in Haryana also.

The present paper attempts to analyse the economics of the poplar tree plantations in blocks in terms of the different age rotations in different size groups of landholdings in the districts of Ambala, Yamunanagar, Karnal, Panipat, Kurukshetra and Kaithal.

Materials and Methods

The study has been based on the primary data collected from the farmers through direct personal investigation with the help of a questionnaire especially designed for the purpose. A three-stage stratified random sampling technique was adopted for the selection of the sample. Keeping in view the similar socio-economic conditions of the farmers and relative wider adoption and concentration of poplar planting in farm forestry, the study area spread over in six districts was amalgamated in three major unit of districts, namely; Ambala (includes Yamunanagar), Kurukshetra (includes Kaithal), and Karnal (includes Panipat). The data was collected, compiled and analysed for the period of 1981-82 to 1991-92. 126 farm holdings were randomly selected from these three major districts of which 46 were from the unit of Ambala and 40 each from Kurukshetra and Karnal. The farmers were classified into three categories of tree growers viz; small,

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medium and large, on the basis of their landholding class as under :

Categories of landholdings	Landholding class
Having land > 2 ha	Small
Having land 2-4 ha	Medium
Having land < 4 ha	Large

The costs involved in tree planting and economic returns of the 4-year, 5-year, 6-year rotation systems in each category of landholdings were analysed in details with a view specially to work out the optimal size category of farms as also the optimal rotation age.

The study is comprehensive in nature having a detailed account of 126 farm holdings regarding the number of trees planted and survived, survival rate, source of seedlings, mode of planting, spacing adopted, age of final harvesting, expenses in terms of the heads of inputs in different years. In the output side revenue received was accounted for the analysis keeping in view the selling method and market conditions.

Analysis of Data

The practice in vogue in appraising forestry projects is to calculate some measures of the project worth that duly take the time element into consideration. The criteria "Cost-Benefit Analysis" adopted for data processing and analysis has been the simple techniques of assessing the commercial profitability of trees grown in a field along with other agricultural crops. The yearwise inputs used for tree planting, maintenance of plantations and the corresponding yields (outputs) were identified, collected, compiled and calculated for each farm for 4, 5 and 6 years rotation periods. One acre (0.40468 ha) has been taken as the unit of landholding (one acre is equivalent to one killa measuring 67 m x 60 m in local unit). Number of trees planted in one acre (0.40468 ha) varies due to variation in spacing adopted. The farmers have planted trees in various geometrical fashion viz; 4m x 3m, 4m x 4m, 5m x 4m, 5m x 5m, etc. It was observed that 5m x 4m and 5m x 5m give good results and caused less loss to agricultural crops because cross harrowing or mechanised agriculture is possible. Keeping, the last two spacing, in view, about 200 trees can be planted in one acre (0.40468 ha).

The costs and benefits are generally spaced overtime from the point of inception of the plantation to the point of its economic demise. To make them comparable, all costs and benefits are normally discounted, by using the same rate of discount, to the rotation age (period). For studying the economic results of the various plantations, the major component of Cost - Benefit Analysis viz; Net Present Value (NPV), Benefit Cost Ratio (B:C ratio), Internal Rate of Return (IRR) and Average Annual Net Returns (AANR) are calculated for 4, 5 and 6 years of rotation which are summarized in Tables 1, 2 and 3.

Results

The main findings and results of the study are summed up as follows :

(i) The study has brought out the fact that the highest NPV and B:C ratio in all the districts are achieved in the 5 year and 6 year rotation (Table 2A and 3A), while the highest IRR has been observed in the case of 4 year rotation. Thus the 5 year and 6 year rotations come out as being economically the most viable and optimum. However, the 4 year rotation is also

Table 1

Economic Analysis of 4 years old Poplar Plantations

(District and Category wise/Acre)

1A. Net Present Value (NPV) in Rupees :

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	—	—	—	22569	20054	17855	33153	29615	26517
Medium	27560	24582	21976	27263	24325	21753	34504	30795	27548
Large	10675	09325	08149	21257	18968	16964	34541	30762	27456

1B. Benefit Cost (B : C) ratio :

Category	Ambala			Kurukshetra			Karnal		
	12%	15% .	18%	12%	15%	18%	12%	15%	18%
Small	—	—	—	6.15	5.82	5.51	8.55	8.12	7.71
Medium	7.74	7.29	6.87	6.81	6.50	6.20	7.34	6.99	6.65
Large	2.81	2.67	2.54	7.40	7.08	6.70	6.69	6.35	6.02

1C. Internal Rate of Return in per cent :

Category	Ambala	Kurukshetra	Karnal
Small	—	133	173
Medium	149	161	163
Large	077	152	147

1D. Average Annual Net Benefit in Rupees :

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	—	—	—	7430	7024	6254	10915	10373	9288
Medium	9073	8610	8169	8976	8120	8086	11360	10786	10240
Large	3514	3266	3029	6998	6644	6306	11372	10775	10206

reasonably profitable and viable, especially where, there is local demand for small size trees and where land is relatively more fertile so that the tree growth by the 4th year is quite substantial to make the trees in adequate sized and market worthy.

(ii) The farm size-wise analysis showed that in the case of small size farms, the 5 year and 6 year rotations are more profitable that the 4 year rotations (Table 1A, 2A and 3A). The district wise analysis showed that in Ambala District, the 5 year rotation with the B:C ratio 6.54, 6.07 and 5.63 at 12 %, 15 % and 18 % discount rate respectively, is more profitable and viable that the 6 year rotation with a corresponding B:C ratio being 4.98, 4.50 and 4.08 (Table 2B and 3B),

Table 2

Economic Analysis of 5 years old Poplar Plantations
(District and Category wise/Acre)

2A. Net Present Value (NPV) in Rupees :

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	33731	29129	25213	28591	24630	21258	38670	33390	28895
Medium	34227	29636	25725	35703	30943	26886	42976	37243	32357
Large	38979	33789	29356	29649	25749	22242	45017	39038	33941

2B. Benefit Cost (B : C) ratio :

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	6.54	6.07	5.63	6.39	5.88	5.42	6.91	6.39	5.92
Medium	8.00	7.40	6.85	8.86	8.20	7.60	8.13	7.54	6.96
Large	8.73	8.05	7.43	9.80	9.10	8.40	8.27	7.72	7.22

2C. Internal Rate of Return in per cent :

Category	Ambala	Kurukshetra	Karnal
Small	098	090	098
Medium	110	117	112
Large	112	121	118

2D. Average Annual Net Returns in Rupees :

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	9357	8690	7874	7931	7347	6638	10727	9960	9023
Medium	9495	8841	8033	9904	9230	8396	11922	11110	10105
Large	10816	10079	9167	8225	7681	7003	12634	11645	10596

in Kurukshetra and Karnal Districts, both, the 5 year and 6 year rotations are equally profitable in the small size farm category.

(iii) As regards the medium size farms in Ambala District, the 6 year rotation [B:C ratio ranging from 6.11 to 5.06 (Table 3B)] is less profitable as compared to the 5 year rotation, being B:C ratio ranging from 8.00 to 6.85 (Table 2B). Similar is the case in Karnal District. However, in the case of the medium size farms in Kurukshetra district with B:C ratio ranging from 6.88 to 10.04 both the 5 year and 6 year rotation are equally profitable and viable (Table 2B).

(iv) In the case of large size category of farms, the 6 year rotation is more profitable than the 4 and 5 year rotation. In Ambala District the large size farmers are getting a higher B : C ratio (8.88 to 10.58) as compared to those in Karnal and Kurukshetra District

Table 3

Economic Analysis of 6 Years old Poplar Plantations
(District and Categorywise/Acre)

3A. Net Present Value (NPV) in Rupees:

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	28240	23448	19483	32616	27491	23238	41930	35104	29441
Medium	32761	27414	22984	42920	36271	30751	49796	41792	35153
Large	43643	36881	31251	36582	30791	25987	63360	53432	48520

3B. Benefit Cost (B:C) ratio:

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	4.98	4.50	4.08	9.10	8.45	7.70	6.53	5.92	5.35
Medium	6.11	5.56	5.06	10.59	9.70	8.88	6.97	6.31	5.71
Large	10.58	9.69	8.88	8.25	7.53	6.88	10.04	9.08	8.22

3C. Internal Rate of Return in per cent:

Category	Ambala	Kurukshetra		Karnal
Small	064	095	075	
Medium	075	105	077	
Large	104	089	092	

3D. Average Annual Net Returns in Rupees:

Category	Ambala			Kurukshetra			Karnal		
	12%	15%	18%	12%	15%	18%	12%	15%	18%
Small	6929	6195	5452	7956	7264	6504	10200	9275	8241
Medium	7968	7251	6433	10439	9582	8607	12112	11403	9840
Large	10615	9743	8747	8897	8136	7274	15410	14118	12648

with B : C ratio ranging from 6.88 to 10.04 (Table 2B).

(v) Of all the three categories of farms, the large size farms in Kurukshetra and Karnal are getting relatively greater profits in all the 3 rotations and show a higher B:C ratio (Table 1B, 2B and 3B) as compared to the small and medium size farms because of, it would seem, the greater availability of resources and technical know how.

Discussions

Though poplar plantation has been found to be more profitable than the traditional agricultural crops in all the districts, the best performance has been observed in the case of Ambala and Yamunanagar Districts. This could be due to the fact that most of the economic factors, influencing the relative viability and profitability of poplar farming, are favourable to these districts. Indeed, the soil and climatic factors as well as the market conditions would seem to be ideally combined in these districts for a profit maximising farm forestry. The reference, of course, is to the soil climatic zone conditioned by the Yamuna river and the large concentration of the wood based industrial units here, along with other technical, financial, entrepreneurial etc. factors. The factors as described above, would seem to make these districts particularly conductive for farm forestry.

Variations in NPV, B:C ratio and IRR have been observed in all the landholding categories and districts under study. These could be ascribed to various factors, viz; variation in the growth rate, size and the girth of trees, market prices, financial capability of the farmer concerned and his capacity to hold back his supply and wait for the right price and market conditions, quantum and cost of imputs used, spacing adopted planting design adopted, type of quality of soil and climatic conditions etc.

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SUMMARY

To improve the biological productivity as well as the economic return of the same piece of land, the different formats of farm forestry include peripheral planting on field boundaries, block plantation along with usual agricultural practices are being adopted in Haryana. The poplar planting has been selected for an indepth study in view of its important contribution towards rural economy. To study the economic results of the various plantations, the major component of Cost-Benefit Analysis viz; Net Present Value (NPV), Benefit Cost Ratio (B : C ratio), Internal Rate of Return (IRR) and Average Annual Net Returns (AANR) are calculated for 4, 5 and 6 years of rotations and poplar planting has been found to be more profitable than the traditional agricultural crops in Ambala, Kurukshetra and Yamunanagar Districts of Haryana.

हरियाणा की क्षेत्र वानिकी का अर्थशास्त्र - अर्थतः सक्षम और परिस्थितितः जीवन क्षम प्रणाली

हरमेन्दर सोढ़ी व एम०वाई० अंसारी

सारांश

जमीन के एक ही टुकड़े से आर्थिक प्रत्याय और उसके साथ-साथ जैविकीय उत्पादकता में परिष्कार लाने के लिए बनाए गए क्षेत्र वानिकी के विभिन्न नमूनों को जिनमें खेतों की मेंडों पर चौतरफा रोपवन लगाना, सामान्य कृषि क्रियाओं के साथ मिलाकर पूरे खण्ड में रोपवन लगाना सम्मिलित है, हरियाणा में अपनाया जा रहा है । यहाँ लगाए पोपलर (वन पिप्पल) रोपण को ग्रामीण अर्थव्यवस्था में इसके महत्त्वपूर्ण योगदान की दृष्टि से गहराई से अध्ययन करने के लिए चुना गया है । विभिन्न रोपवनों के आर्थिक परिणामों का अध्ययन करने के लिए लागत-लाभ विश्लेषण के बड़े संघटकों, शुद्ध प्रतिशत मूल्य, लाभ-लागत अनुपात, प्रत्याय की आंतरिक दर और औसत वार्षिक शुद्ध प्रत्याय की गणनाएँ 4, 5 और 6 वर्षों का आवर्तन रखने पर की गई हैं तथा ऐसा करने पर हरियाणा के अम्बाला, कुरूक्षेत्र और यमुनानगर जिलों में पारम्परिक कृषि फसलों की तुलना में पोपलर (वन पिप्पल) लगाना अधि लाभप्रद पाया गया है ।

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FOREST : A COMPONENT OF FARMING SYSTEMS IN HIMACHAL PRADESH

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Introduction

Forests are both products and components in the context of inputs into the ecosystem. Forests supply both tangible and intangible benefits, it provides directly extractable products like timber, fodder, fuel, food etc; and indirect services in the form of contribution to biodiversity, moisture and nutrients circulations, and make up the stability of environment. In other words, both these items recognises the 'product' and 'input' dimension of the forest in an ecosystem context. Forests perform various functions without internal bio-chemical, biophysical, and other forms of subsidisation. Forests, as a living natural resource, performs most of the function simultaneously. The extent of each function, however, depends on biophysical and other resource base components of the forest in a given area (Singh, 1995).

Broadly two type of functions are being performed by forests and these are (i) service functions (e.g. contribution to biodiversity, nutrition and moisture circulations) and (ii) product functions (e.g. land intensive resource use system or source of diverse biomass). Both these functions have been given due recognition in new Forest Conservation Acts of 1980 and 1988. The National Forest Policy Resolution of 1988 had accepted environmental stability and maintenance of ecological balance as the principal aim of forest policy (Kulkarni, 1994). However in practice, not only the forests 'service function' are pushed into the background, but even the 'product functions' are separated through various legal and administrative impositions. Accordingly different parts of forests are classified as protected or reserved forests, commercial forests, community forest etc. By this implication uses are also fixed (e.g. forest for industrial raw material, forest for meeting sustenance needs of the communities etc.). This sort of disintegration of the functions of forest is against the approach of sustainable use of forest resources. This is more in mountain areas where not only the separation of the above "service function" and "product functions" as explained in Table 1 is more difficult, but different users of forests are very much interdependent. The latter happens due to factors such as forest-farming linkages, complementarities between land extensive and land intensive patterns of resource use etc. In order to understand the role of different functions of forest as a component of farming system in mountain areas, an attempt has been made in this paper to assess the contribution of forest in farming system of Himachal Pradesh.

Area and Types of Forests

Broadly two types of forests are classified in Himachal Pradesh (Table 1) and these are culturable forests i.e. having tree plantations and unculturable forests consisting of barren, pasture and scrub forest lands. Total forest land accounts for 67.52 per cent of geographical area of the State and out of which culturable forest was 38.20 per cent during 1988-89 and 1990-91. This class of forest land is considered for commercial exploitation of forest wealth while unculturable forest (29.22 %) land is considered for development/extension of tree cover under various forestry programmes (Anon., 1987-88). The distribution of forest area in the State is not uniform. In lower and mid-hills, forest have receded to area not fit for agriculture and are generally of broad leaf species. In higher reaches except in snow desert area of Kinnaur and Lahaul Spiti districts, forest cover a substantial proportion of geographical area and are of pines.

Forest and Hill Farming Systems

Farming system in hills have acquired a number of features to manage problems and opportunities created by mountain characteristics such as, inaccessibility, fragility, and diversity (Jodha, 1989a). They are clearly visible in the hilly areas of Himachal Pradesh, covering about 12 per cent (arable land) of the total physical area and containing more than 90 per cent of State population. The farming system consists of great variety of crops, including perennial fruit and fodder trees and different

Table 1

Forest Resources of Himachal Pradesh

(Hectares)

Category	1970-71	1980-81	1988-89	1990-91
Culturable forest land	2143538 (38.51)	2116847 (38.02)	2132500 (38.30)	2132500 (38.30)
Unculturable forest land	1409261 (25.32)	1585928 (28.49)	1626640 (29.22)	1626640 (29.22)
Total forest land (1)	3552799 (63.83)	3702775 (66.51)	3759140 (67.52)	3759140 (67.52)
Forest cover (2) as % of Geographi. area	NA	12882(87) (23.14)	13377(89) (24.03)	11780 (21.20)
Total Geographi. area	5565800 (100)	5567300 (100)	5567300 (100)	5567300 (100)
Per Capita Forest Land (3)	1.03	0.87	0.76	0.72

Source : (1) Department of Forest, Himachal Pradesh, Shimla.
(2) The State of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Govt. of India, Dehradun, 1988 & 1993.
(3) Based on population census, Govt. of India, 1971, 1981, 1991 and projected population for 1988-89.

Note : Figure in brackets denote percentage of respective totals.

species of livestock. The system produces food year-round, and provides continuous employment for unskilled labour to grow crops and tend livestock. The system is highly labour intensive and depends to a large extent on the available forests and non-arable land. Forests are as integral a part of farming system as arable land and livestock. Forests supply fuelwood, fodder, compost, timber, staking and fencing material and food to the system. Thus, crop production, animal husbandry and forestry constitute the three main closely and inseparably integrated component in hill farming systems (Mahat, 1987). The farmers in hills have always understand these linkages and closely integrated all components for their sustenance. However, despite the recognition of this fact very little has been done on quantification of evidence of it. In the present study an attempt has been made to value the production and service function of forest attributed as component of farming system in Himachal Pradesh.

Valuation Procedure of Forest Contribution

The study is broadly based on field data collected by authors for various field studies conducted in Himachal Pradesh (Singh, 1990, 1992, 1993 and 1994). Keeping in view the mountain specificities, the farming systems identified and considered in the present study are animal husbandry, foodgrain farming, vegetable farming and fruit farming. The agro-climatic conditions clearly demarcated the above systems prevailing in different region of the State. Forests directly influence production by supplying various inputs needed for production in the form of creator and contributor to the production process. These attributes are listed in Table 2. The exercise followed for assigning the money value of forest products being used and influenced farming systems is listed below :

Direct products : Value imputed on the basis of quantity used and prevailing local rates (cost) of products (e.g. grasses, leaves, bushes, twigs, timber and water for irrigation). Shadow price is also taken as value of product for which local rate/price is not available (Singh, 1992; Bhati *et al.*, 1992).

Indirect products : Value estimated on the basis of established norms and scientific findings already available (Gupta, 1990).

Role of Forests in Livestock Rearing

Forests are more closely linked with livestock as compare to other component of the mountain farming system. The number of livestock kept per household in hills is mainly determined by the available forest and grazing land in the area. Forest provides feed and bedding material to the livestock (Table 2). In high hills mountain region of the State livestock rearing dominates the farming systems. The crop production accounts 4.28 per cent of land area while forest lands for more than 90 per cent of physical area. Under livestock farming system an average household collects 13,246 kg of dry weight fodder in the form of grasses and leaves annually from forest lands (Singh, 1992). And out of this quantity 10 per cent is collected as cut fodder while 69 per cent by way of grazing. All these forestry products contributes 49 per cent of total value/cost of inputs needed for the livestock production (Table 3). The total output generated from livestock rearing is estimated to be Rs. 8,457 per farm annually.

Table 2

Attributes of Forest as Component of Farming System.

Attributes of Forest	Farming Systems			
	Livestock Production	Foodgrain Production	Vegetable Production	Fruit Production
Creator for Production of :				
Grasses	Fodder	—	Mulching	Packing
Leaves	Litter	Composting	Composting & Mulching	Composting & Mulching
Bushes	Litter	Fencing	Fencing	—
Twigs/branches	Housing	—	Staking	—
Timber	Housing	Implements	Packing	Packing
Contributor to :				
Moisture circulation	—	Irrigation	Irrigation	Irrigation
Nutrient circulation	—	Soil fertility	Soil fertility	Soil fertility
Environment stability	—	Plant protection	Plant protection	Plant protection

Table 3

Average contribution of forestry sector to different agricultural sub-sectors in Himachal Pradesh.

Farming system	Forest as Production Fuction		Forest as Service Function		Production Cost/Value		Total Output
	Forest contri-bution (Rs)	Share in total cost (%)	Forest contri-bution (Rs)	Share in total cost (%)	Forest share (%)	Total (Rs)	(Rs)
Livestock Prod. (Rs/Farm)	2835	49	-	-	49	5777	8457
Food Grain Prod. (Rs/ha)	253	12	149	7	19	2067	2961
Vegetable Prod. (Rs/ha)	2964	21	697	5	26	14018	24180
Fruit Prod. (Rs/ha)	5740	19	435	1	20	29754	47955

Source : Compiled by the Author.

Role of Forests in Foodgrain Farming

In dry land farming system, service function of forest directly influence the foodgrain production to a great extent. In Himachal Pradesh more than 80 per cent area of foodgrain crops is under dryland farming. Generally these crops are grown on natural precipitation in the form of direct rain water and moisture circulation from forest lands. Forest lands provides water for irrigation from its numerous streams and rivulets. Forest also enrich soil fertility by way of nutrient circulation (e.g. fallen leaves and other composting material increases humus contents and this in turn improves soil health). According to one scientific study natural mixed deciduous forests are said to return by leaf-litter about Rs 416 per ha/pa of N, Rs 152 of P and Rs 139 of K (Gupta, 1990). Forest also provides fencing material and wood for farm implements. All these factors of production flowing from forests contributes 19 per cent share in total cost of foodgrain production in Himachal Pradesh (Table 3). Out of these direct inputs received from forests, constitute 12 per cent of total cost and remaining 7 per cent in the form of indirect benefits.

Role of Forests in Vegetable Farming

The important vegetables grown in the State are green peas, tomatoes, cauliflower, cabbage, capsicum, beans, etc. These vegetables are produced during that period in various parts of the State when these are not available in the plains of Northern India. This is all for reasons of the higher altitude and consequently cold climate of the State. The large tract of forests and pastures (e.g. agricultural support land supplying various kind of direct and indirect inputs) induced Himachal farmers to takeup the production of these vegetables on commercial scale (Singh, 1992). It is more so after attainment of statehood in 1971, there has been a rapid development of network for the marketing of perishables. This system need small land base and Himachal being State of small land holders, the vegetable farming become so popular during recent decade (Singh, 1990).

The system is labour intensive and requires much more inputs compared to other systems. Forests directly influence vegetable production by supplying composting, mulching and staking material essentially required for the production process. Forests also supplements moisture and nutrient and prevent crop damages by plant diseases. Unlike other systems vegetable production is highly dependent on forest resources. Direct inputs flow from forests constitute 21 per cent share in total cost of production while both direct and indirect contributes for 26 per cent of cost/value of production (Table 3). The dependence on forests for staking and other material is so high that with the depletion of forests the area under vegetables become sensitive to the availability of these resources. Due to increase in acreage under vegetables the extraction/exploitation rate become so high that the resources are degrading at a faster rate.

Role of Forests in Fruit Farming

Himachal Pradesh is known for temperate fruit production. The apple produced in the State are known for their delicious quality and taste and for this reason this State is widely recognised as Apple State of India (Azad *et al.*, 1988). Fruit cultivation requires lot of good timber for post-harvest handling of output. Packing material accounts for about 12 per cent of total marketing cost in apple production. Almost all the packing material was received from forest till late 90s. In Himachal Pradesh the quantity required for packing of fruits and vegetables during 1987 was estimated to be 187,800 m^3 and same was projected to be 412,800 m^3 in 1996 (Azad *et al.*, 1988). In recent years with the high rate of forest depletion the State Govt. has stopped the supply of subsidized timber for packing cases. Consequently, carton/non-wood packing material is being used in fruit farming. The share of forest in fruit farming is estimated to be 20 per cent of total cost of production and out of this 19 per cent in the form of direct inputs (Table 3).

In addition to farming systems, forests in hills are also providing numerous items to the hill people. Among those supply of domestic energy items are important one. Each household fulfills more than 50 per cent of his energy requirement from forests (Singh, 1993). The marginal and small land owners are much more dependent on forests for their domestic energy needs.

Conclusion and Suggestions

Sustainability issued in context of linkages between forest and farming system : In mountain perspectives the role of forest in hill farming system is altogether different to plain areas as the same provides various kinds of inputs to the farm production. The relationship explained in Table 2 clearly indicates that to achieve sustainable development of Himalayan forests, forest usage and development will have to be treated as an integrated part of overall resource use-pattern and people's sustenance. To compensate the present use of forest resources it is useful to supplement the conventional monetary accounting procedures by a system of compensation in "biophysical terms" as has been tried in some irrigation projects in India (Jodha, 1990). A simple approach is, the provision of planting one or more tree for each removed. It is further suggested that to maintain diversity and associated circumstances planting of not only trees of some species, but also of the previous existing surrounding vegetation. Though the proposed New Forest Act envisage the people's participation for the development and conservation of public forests under Joint Forest Management programme, the success is doubtful. Therefore the best option, is to provide technical know-how and area specific plant material to the forest users for the development of forestry resources on their private land as well as on community lands.

SUMMARY

Forests are as integral a part of farming system as arable land and livestock. Thus, crop production, animal husbandry and forestry constitute the three main closely and inseparably integrated component in hill farming system. Forests are more closely linked with livestock as compare to other component of the mountain farming system. The number of livestock kept per household in hills is mainly determined by the available forest and grazing land in the area. Forest provides feed and bedding material to the livestock and these inputs constitute 49 per cent of total cost of production. Similarly forests contributes 19, 20 and 26 per cent in total cost of production of foodgrain, fruits and vegetable, respectively. Besides these contributions, forests fulfils more than 90 per cent domestic energy requirement of hill people and out of which public forests accounts for 50 per cent of total requirement. An attempt has been made in this paper to assess the contribution of forest in farming system of the State.

हिमाचल प्रदेश की कृषि प्रणालियों का एक संघटक : वन

डी०वी० सिंह

सारांश

कृषि प्रणाली का वन उतना ही अभिन्न अंग है जितना कि कृष्य भूमि और पशुधन । पर्वतीय कृषि प्रणाली के अन्य संघटकों की तुलना में वन पशु-पालन के साथ कुछ ज्यादा ही निकटता से जुड़े हुए हैं । पहाड़ों में प्रत्येक घर के साथ रखे जाने वाले पशुओं की संख्या का विनिश्चय क्षेत्र में उपलब्ध वनों और चराई क्षेत्र के आधार पर किया जाता है । वन पशुओं को चारा और बाड़ा बनाने की सामग्री उपलब्ध कराते हैं और उन पर किया जाने वाला निवेश उत्पादन की कुल लागत का 49% होता है । इसी तरह से खाद्यान्न, फलों और सब्जियों के उत्पादन की कुल लागत में वनों का योगदान क्रमशः 19, 20 और 26% होता है । इस योगदान के अतिरिक्त पहाड़ी लोगों की घरेलू उर्जा आवश्यकता का 90% से अधिक भाग वनों से ही पूरा होता है जिसमें से कुल आवश्यकता का 50% भाग सार्वजनिक या सरकारी वनों से मिलता है । इस लेख में प्रदेश की कृषि प्रणाली पर वनों का अंशदान आकलन विवरण है ।

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EXISTING AGROFORESTRY SYSTEMS AND PRACTICES IN MANIPUR

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Introduction

Manipur is basically an agricultural state with some small scale industries here and there. The main trading items are Agricultural and forest products followed by the products of Handloom, Pottery, Blacksmithy etc. The soil range from loamy clay to sandy alluvial with heavy rainfall and occasional rains in winter. Manipur may be divided into Western and Eastern regions. The average temperature regime is 0^0-12^0C in winter and 28^0-29^0C in summer in the eastern aspects whereas it exceeds 36^0C in summer in the western aspects. Settled or wet terrace cultivation is practiced in the villages which is permitted by the topography with feasibility of double or multiple croppings. However on the contrary, most of the hill people still practice the sustenance type of cultivation i.e. Jhuming as they are landless and economically poor. There was no systematic agroforestry system existing in the State till a decade ago.

Concepts

For the last 5 years the division of agroforestry, ICAR Manipur Centre has been trying to evolve the best agroforestry practices suitable for the State incorporating the indigenous multipurpose trees, shrubs and herbs in addition to un-introduced exotic species. Surveyed on the existing agroforestry systems in the 5 hill districts (Survey data enclosed) indicates the extent of system(s) applications in vogue and future need based technologies that can be used are suggested.

The prevailing conditions and situations if allowed to continue may go out of our hand culminating in the final disaster. The present stage and mode of exploitation of forests and their products, farming systems, soil and water dynamics especially in the hills are already highly alarming in the ecological and environmental point of view. Thus it seems to be obvious that new technologies becomes inevitable to counter the depleting and degrading environment for the whole State. We have identified the following multipurpose and indigenous forest tree species easily propagable and suitable for Silvi-Pastoral system, Silvi-Horticultural system.

Silviculture sp.: *Albizia* species (*A. stipulata, A. lucida, A. odoratissima*), *Alnus nepalensis, Artocarpus* species, *Ailenthus excelsa, Bauhinia purpurea, B. variegata, Bombex ceiba, Gmelina arborea, Juglans regia, Kydia caloyoina* and other species *Litsea polyantha, Mercaranga denticulata, Melia azadirachta, Michelia* species, *Phoebe* *hainesiana, Parkia javanica, Pinus kesiya, Quercus* species, *Santalum album, Schima wallichii, Syzygium* species, *Tectona grandis, Terminalia bellirica* etc.

Fodder Tree spp.: *Acacia farnesiana, Artocarpus* species (*A. integrefolia, A. lakoocha,*) *Bauhinia purpurea, B. variegata, Erythrina suberosa, E. indica, Grewia optiva, Kydia calycina* etc. and other available species, *Litsea polyantha*, available *Musa* species and all the available species of *Ficus*.

Horticulture Fruit Crop spp.: *Artocarpus integrefolia, A. lakoocha, Averrhoea carambola, Elaeocarpus serratus, Malus baccata, Juglans regia, Magnifera indica, Musa* species, *Oroxylum indicum, Parkia roxburghii, Phyllanthus emblica, Punica granatum, Pyrus communies, Psidium guajava* etc. in addition to all the available *Citrus* and *Prunus* species.

Results and Discussions

The results relating to Agroforestry systems and practices in Manipur may be summarized as follows (Table 1) :

(1) The farmers in hill districts of Manipur are not enlightened on proper farming or agroforestry systems. The farmers are not aware of the beneficial efforts of plannings viz. fruit orchards, costly terrace constructions etc. as they are not assured of lifelong tenureship.

(2) Jhuming on the less forested or degraded hill slopes is more disastrous than on the more wooded hill slopes where there are chances of quick regeneration of the vegetative cover. Cattle farming, generally practiced by the Nepalies in the hill is also worth mentioning. The naturally available indigenous fodder trees such as *Bauhinia* species, *Ficus* species, *Artocarpus* species, *Litsea polyantha* etc. are dwindling fast due to lopping or pollarding for fodder and stunted stumps with short branches and some leaves are the mute witness of their existence.

(3) Though the actual agroforestry systems are not followed scrupulously some people residing in Ukhrul (east) District are following the applausive silviculture or the true type of afforestation. Here the farmers are having their separately owned forested hill slopes, which they used to harvest the matured trees such as *Pinus kesiya, Phoebe hainesiana, Mechelia montana, Schima wallichii, Ailanthus excelsa, Quercus* species etc. They replant locally available and abundant seedlings of *Litsea polyantha, Alnus nepalensis, Schima wallichii* etc. in the inter spaces. Thus they can manage properly and exploit economically the alloted patch of forested hill slope.

(4) A comparison-cum-performance trials on contour terracing, contour trenching and half moon terracing with various agroforestry systems were started at Krishnagiri Langol Farm to evolve suitable systems in relation to the existing agro-climatic conditions of the State.

Suggestions

(1) *Environmental Education and Trainings* on Agroforestry should be imparted to the farmers as well as to the general public to create environmental awareness.

(2) *Training Centres and Camps* should be organised by the competent authorities at block level and school level.

(3) *Land holding system* should be improve

Table 1

Survey on existing Agroforestry system in Manipur

	District				
	Chandel	Ukhrul	Senapati	Tamenglong	Churachandpur
1	2	3	4	5	6
I. Identification					
(1) Literacy per cent	17.83%	22.98%	18.73%	4.6%	14.42%
(2) Distance from the metalled road (km) Min. & Max.	0-12 km	0-9.6 km	0-15 km	0-20 km	1-25 km
(3) Distance from B.D.O. (kms) Min. & Max.	45-75 km	14.4-79 km	0-50 km	8-115 km	6-25 km
II. Family Data (Average)					
(1) Size of the family	5.52	6.24	5.72	5.72	6.24
(2) Male & female ratio	16 : 17	13 : 12	1.08 : 1.05	1 : 1	1.84 : 1.96
(3) Average occupation	*Main Subs.*	*Main Subs.*	*Main Subs.*	*Main Subs.*	*Main Subs.*
(a) Farming	2.16 0.48	2.64 0.6	2.36 0.52	2.84 0.68	3.2 0.6
III. Operational Land Holding (ha)					
(1) Irrigated	0.31 ha	1.19 ha	1.42 ha	0.75 ha	0.66 ha
(2) Unirrigated	0.34 ha	0.72 ha	0.65 ha	0.44 ha	0.32 ha
(3) Area under jhum	1.14 ha	0.34 ha	Negligible	0.91 ha	0.98 ha
(4) Village community	-	-	-	-	-
(5) Own	-	-	-	-	-
(6) Homestead	0.7 ac.	0.8 ac.	0.93 ac.	0.69 ac.	0.82 ac.
(7) Under cultivation	-	-	-	-	-
(8) Kept fallow	-	-	-	-	-
(9) Under Hort. crops	0.34 ac.	0.88 ac.	0.82 ac.	0.9 ac.	1.24 ac.
(10) Under pasture	-	-	-	-	-
(11) Under tree plantation	N.P.S*	0.68 ha	0.22 ha	-	N.P.S.
(12) Leased out	0.11 ha	0.07 ha	0.44 ha	0.06 ha	0.14 ha
(13) Leased in	0.02 ha	-	-	-	0.08 ha
(14) Under pisciculture	0.02 ha	0.87 ac.	0.03 ac.	0.06 ac.	0.13 ac
(15) Land Revenue	-	-	-	-	-

Contd...

1	2	3	4	5	6
IV. Particulars about livestock and fishery					
(1) Cattle :					
(a) Cow	0.32	1.56	6.56	1.4	3.32
(No. in production)	0.08	0.24	1.65	0.16	0.68
(b) Buffalo	-	0.96	1.08	1.44	0.52
(c) Mithun	1.4	-	-	0.32	-
(2) Pig	2.56	1.44	2.68	3.92	4.6
(3) Poultry	17.48	23.56	15.6	18.08	25.84
(4) Fisheries	60.00	500.00	NPS	NPS	80.00
V. Annual Income					
(1) Agril. crops (a) Paddy	37 Phoubots**	63.52 Phoubots	51.72 Phoubots	58.52 Phoubots	58.40 Phoubots
(b) Maize	0.38 Qtl.	1.18 Qtl.	0.37 Qtl.	-	N.P.S.
(2) Fruit crops	Rs. 608.00	Rs. 846.00	Rs. 988.00	Rs. 1,760.00	Rs. 1,474.00
(3) Animal Husbandry	Rs. 4,882.00	Rs. 3,290.00	Rs. 10,324.00	Rs. 4,530.00	Rs. 2,746.00
(4) Tree crops	N.P.S	Rs. 1,088.00	N.P.S.	N.P.S.	N.P.S.
(5) Fish produce	Rs. 20.00	Rs. 1,104.00	N.P.S.	N.P.S.	Rs. 40.00
(6) Vegetable crops	Rs. 504.00	Rs. 2,084.00	Rs. 1,988.00	Rs. 2,042.00	Rs. 478.00
VI. Soil Conservation measures					
(a) Soil (Top)	Clayed-loamed	Clayed-loamed	Clayed-loamed (Black)	Clayed-loamed (Black)	Clayed-loamed
Particulars (Area under) :					
(1) Contour bunding	-	-	-	-	-
(2) Terracing	0.31 ha	1.19 ha	1.42 ha	1.04 ha	0.80 ha
(3) Half moon terracing	-	-	-	-	-
(4) Sowing of crops in line along or across the slope (including pine apple)	-	1.12 ha	0.5 ha	0.08 ha	0.09 ha
(5) Others	-	-	-	-	-
(b) Water harvesting (Pond etc.)	-	-	-	-	-
(c) Correction of soil acidity (Soil amendment, liming etc.)	-	-	-	-	-

Contd...

1	2	3	4	5	6
VII. Crops grown :					
(1) Agril. crops	1.5 ha	1.62 ha	1.48 ha	1.72 ha	1.78 ha
(2) Vegetable crops	0.91 ac.	1.19 ac.	1.21 ac.	1.15 ac.	0.81 ac.
(3) Fruit crops	0.34 ac.	0.89 ac.	0.82 ac.	0.90 ac.	1.24 ac.
(4) Tree crops	Negligible	0.73 ha	0.22 ha	Negligible	Negligible
VIII. Sources of Agricultural inputs :					
(1) Seeds & seedlings	Local & Bazar	Local & Bazar	Local, Bazar & Blocks	Local & Bazar	Local & Bazar
(2) Manure/Fertilizers	-	-	Local	-	-
(3) Insecticides/Fungicides	-	-	-	-	-
(4) Loans/Grants	-	-	-	-	-
IX. Market/Disposal facilities of the Farm products	Easy	Difficult	Easy	Difficult	Difficult
X. Transportation (Mode)/ Communication :	Motor Vehicle	Motor Vehicle	Motor Vehicle	Head load & Motor Vehicle	Motor Vehicle, Horses
XI. Application of Manure and Fertilizer	Negligible	Negligible	Animal	Nil	Negligible
XII. Application of Insecticides/ Fungicides	Negligible	Negligible	Negligible	Nil	Negligible
XIII. Constraints faced by the Farmers :	Mostly steep hill slopes & lack of input and plant protection measures	Lack of input and plant protection measures.	-	Lack of transport and input facilities are the biggest problem.	Steep hills and lack of motorable roads etc.

Subs = Subsidiary

* N.P.S. : Not in production stage or for only family consumption.

** 1 Phoubot of Paddy =65 kg in the hill, and 60 kg in the valley.

especially in the hill districts by enacting suitable acts.

(4) *A co-ordinated effort with available resources* should be initiated for the ecological repairs. Experts should select suitable crops.

(5) Total destructions of the tree stumps after harvest or jungle clearing should be avoided as far as possible to check moisture and soil losses before ecological repair is practically achieved.

(6) The luxuriant and abundantly available leaves of *Quercus* species may supplement the Bidi rolling leaves. Possibilities should be explored which can be exploited economically.

SUMMARY

The Division of Agroforestry, ICAR, Manipur Center, Imphal has carried out a pre-emptive survey on the existing agroforestry systems and practices in the 5 hill districts of the State and identified/encountered the problems faced and the required need based Technologies by the hill farmers. Research on Silvi-horticulture, Silver-pastoral (Horti-pastoral), Agri-Silvi-Pastoral, Agri-Horti-Pastoral systems with both indigenous as well as exotic tree species at ICAR Krishnagiri Langol Farm are giving encouraging results. The main agricultural crops inter-cropped in the systems are *Zea mays, Cajanus cajan, Vigna unguiculate* **and others, while** *Pemphis purpureum* **(Elephant grass)** *Penisetum pedicellatum, Teosinte, Changning* **etc. are the main fodder grasses having bright prospects. The multipurpose tree incorporated are** *Parkia roxburghii, Litsea polyantha, Alnus nepalensis* **etc. and available species of** *Albizia, Artocarpus, Ficus* **are more useful for Agroforestry systems.**

मणिपुर की वर्तमान कृषि वानिकी प्रणालियां और व्यवहार

रमेश सिंह, एल०एल० सिम्टे व रघुमणी सिंह

सारांश

भारतीय कृषि अनुसंधान परिषद के कृषिवानिकी विभाग, मणिपुर केन्द्र ने इस राज्य के पांच पहाड़ी जिलों की कृषि वानिकी प्रणालियों और व्यवहार का अग्रिम सर्वेक्षण किया और पहाड़ी किसानों के सामने आने वाली समस्याओं और उनकी आवश्यकताओं पर आधारित प्रौद्योगिकियों को पहचाना/पता लगाया । भारतीय कृषि अनुसंधान परिषद के कृष्णागिरि लांगोल प्रक्षेत्र में देशी और परदेशी दोनों तरह की वृक्ष जातियाँ लेकर वन-औद्योयानिकी, वन-पशु-चराई (उद्यान-गोचर), कृषि-वन-गोचर, कृषि - उद्यान - गोचर प्रणालियों पर किए अनुसंधानों से उत्साहप्रद परिणाम मिल रहे हैं । इन प्रणालियों के साथ बीच में लगाई जाने वाली फसलों में *जिया मेज, काजानुस काजान, विग्ना उनगुइकुलाटे* (रणभाष) इत्यादि रही जबकि अच्छी संभावना वाली मुख्य चारा घासों में *पेम्फिस पर्पूरियम* (हाथी घास), *पैनिसेटम पेडिसेल्लेटुम, टेओसिन्ते, चांगनिंग* इत्यादि रही । इसमें लिए गए बहुप्रयोजन वृक्ष रहे *पार्किया राक्सबर्धिआई, लिटसिया पोलिएंथा, एल्नस नेपालेंसिस* इत्यादि तथा *एल्बिज्जिया, आर्टोकार्पुस, फाइक्स* की उपलब्ध जातियाँ कृषि-वानिकी प्रणालियों के लिए अधिक उपयोगी पाई गई ।

PROMINENT AGROFORESTRY SYSTEMS AND IMPORTANT MULTIPURPOSE TREES IN FARMING SYSTEM OF MIZORAM

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Introduction

A large number of multipurpose trees and shrubs are deliberately left or introduced in cropping system in Mizoram. Production of agricultural crops are the main source of subsistence because 80 per cent population are dependent upon agriculture. Combining of trees, crops and livestock is in practice since long. This has resulted various kinds of agroforestry system.

The aim of the paper is to discuss various multipurpose tree species and predominant agroforestry system as a substantial means of productivity and livelihood. The productivity of these traditional managed and lesser studied agroforestry system can considerably improved by scientific intervention.

Biophysical Environment

Mizoram is triangular in shape, perched in the North-east by Assam and Manipur in the North, Burma and Chittagong Hill Tracts in the South, Myanmar in the East and Tripura and Bangladesh in the West. The Tropic of Cancer passes through the middle portion of the State and lying in between latitude 20.20⁰ - 24.27⁰N and longitude 92.20⁰-93⁰E. The total geographical area is 21,09,382 hactares endowed with a number of physiographic units, viz; ridges, escarpment, very steep, steep side sloped, flat land and narrow valleys.

The foothills and the narrow valleys with hot and monsoon rain climate has the soil order of ultisols and temperate climates with tropical evergreen/semi-evergreen and mountane sub-tropical forests.

Crops and Multipurpose tree species in Farming systems

Most of the area under agriculture is rainfed. The western low lying area of land receives south-west monsoon as the first monsoon (March-May) which is suitable for rabi crops and the second monsoon prevailing in Aug.-Oct. favours the kharif crops. The most common agriculture crops and multipurpose tree grown under different agroforestry system are given in Table 1 and 2.

Table 1

Agricultural crops grown along with tree species

Crops/Species.	No of farms in which grown (out of 100 farms surveyed).
1	2
Dolichos lablab	62
Phaseolus mungo	15
Brassica oleracea var. *capitata*	55
Colocasia esculenta	89
Brassica oleracea var. *botytris*	45

Contd...

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1	2
Capsicum annuum	75
Sechium edule	35
Gossipium arboreum	26
Vigna sinensis	98
Cucumis sativus	100
Phaseolus vulgaries	90
Zingiber officinale	81
Arachis hypogea	42
Abelmoschus esculentus	72
Lens esculentus	20
Brassica campestris	100
Zea mays	100
Oryza sativa	100
Pisum sativum	50
Solanum tuberosum	45
Cucurbita moschata	100
Sesamum orientale	65
Cucurbita maxima	92
Saccarum officinarum	45
Ipomoea batatas	86
Manihot esculenta	68
Nicotiana tabacum	63
Lycopersicon esculentum	25
Curcuma longa	32
Dioscorea alata	25

Table 2

Multipurpose trees and shrubs recorded in farms of Mizoram

Botanical name	Type	Main use
1	2	3
Acrocarpus fraxinifolius	T	Fodder, fuelwood.
Adhatoda vasica	S	Livefence, erosion control, medicinal.
Albizia lebbek	T	Timber, fuelwood.
Aleurites fordii	T	Seed oil, fuelwood.
Areca catechu	T	Masticatomy nut.
Artocarpus heterophyllus	T	Fruit, food seeds, fodder leaves, timber.
Artocarpus lakoocha	T	Fodder, fruit, fuel, medicinal.
Bassia butyracea	T	Seed oil, timber, medicinal.
Bambusa tulda	T	Fodder, fuel, timber.
Bauhinia variegata	T	Fodder, fuel, fruit.
Bischofia javanica	T	Fodder, fuel, medicinal.
Callicarpa arborea	T	Fodder, fuel, bark medicinal.
Clerondendron colebrookianum	ST	Leaves vegetable, mecicinal, prevent soil erosion.
Cinnamomum cecidodaphne	T	Timber, fuel, medicinal.
Cinnamomum zeylanicum	T	Spice, fuel.
Dendrocalamus stictus	T	Fodder, fuel.
Dysoxylum gabora	T	Timber, leaves, vegetable, fuel.
Erythrina spp.	T	Fodder, fuel, fences, support.
Ficus bengalensis	T	Fodder, ornamental, soil erosion control.
Ficus religiosa	T	Fodder, shade, soil erosion control.
Ficus semicordata	T	Fodder, fruit.
Gmelina arborea	T	Fodder, fuel, timber, medicinal.
Grevilea robusta	T	Timber, windbreak.
Grewia multiflora	T	Fodder, fuel.
Leucaena leucocephala	S	Fruit, fodder, medicinal, vegetable.
Litchi chinensis	T	Fruit, timber, food stuff, feeding stuff.
Mangifera indica	T	Fruit, fuel.
Mesua ferrea	T	Timber, shade, medicinal, windbreak.
Michelia champaca	T	Timber, fuelwood, plywood,windbreake
Morus alba	T	Timber, fodder, fuel, fruit.
Moringa pterygosperma	T	Leaves, vegetable, flowers and bark, medicinal, seed-oil.
Musa spp.	T	Fruit, mulch, papermaking.
Parkia roxburghii	T	Fruit, soil erosion control.
Prunus cerasoides	T	Fodder, fuel, timber.
Psidium guava	T	Fruit, fuel, medicinal.
Pterospermum marsupium	T	Timber, fodder, fuel.
Punica granatum	ST	Fodder, fuel, fruit, medicinal.
Pyrus communis	T	Fruit, fodder, fuel.
Rhus accuminata	T	Fodder, fuel.
Rhus javanica	T	Fodder, fuel, fruit.
Salmalia malabarica		Fuel, timber, spice.
Schima wallichii	T	Fodder, fuel, timber, medicinal.
Syzygium spp.	T	Fodder, fuel, medicinal.

(Contd...)

1	2	3
Taractogenos kurzii	T	Seed-oil, nut juice for ink varnish, medicinal for leprosy.
Tectona grandis	T	Timber, fuel.
Trevesia palmata	ST	Fruit, hedgerow.
Ziziphus jujuba	ST	Fruit, fodder.
Zanthozylum rhetsa	T	Leaves, vegetables, fuel.

* T = Tree ** S = Shrub *** ST = Small Tree.

Agroforestry systems in Traditional farming system

The Agroforestry systems prevalent in the Mizoram include various forms of combination of trees and food crops (Table 3). Additionally, some improvements to Jhum cultivation are also being tried in several place under a centrally sponsored Jhum Control Project -1987. This scheme does not hold good as farmers have to tide over 5-6 year transitional period to generate income.

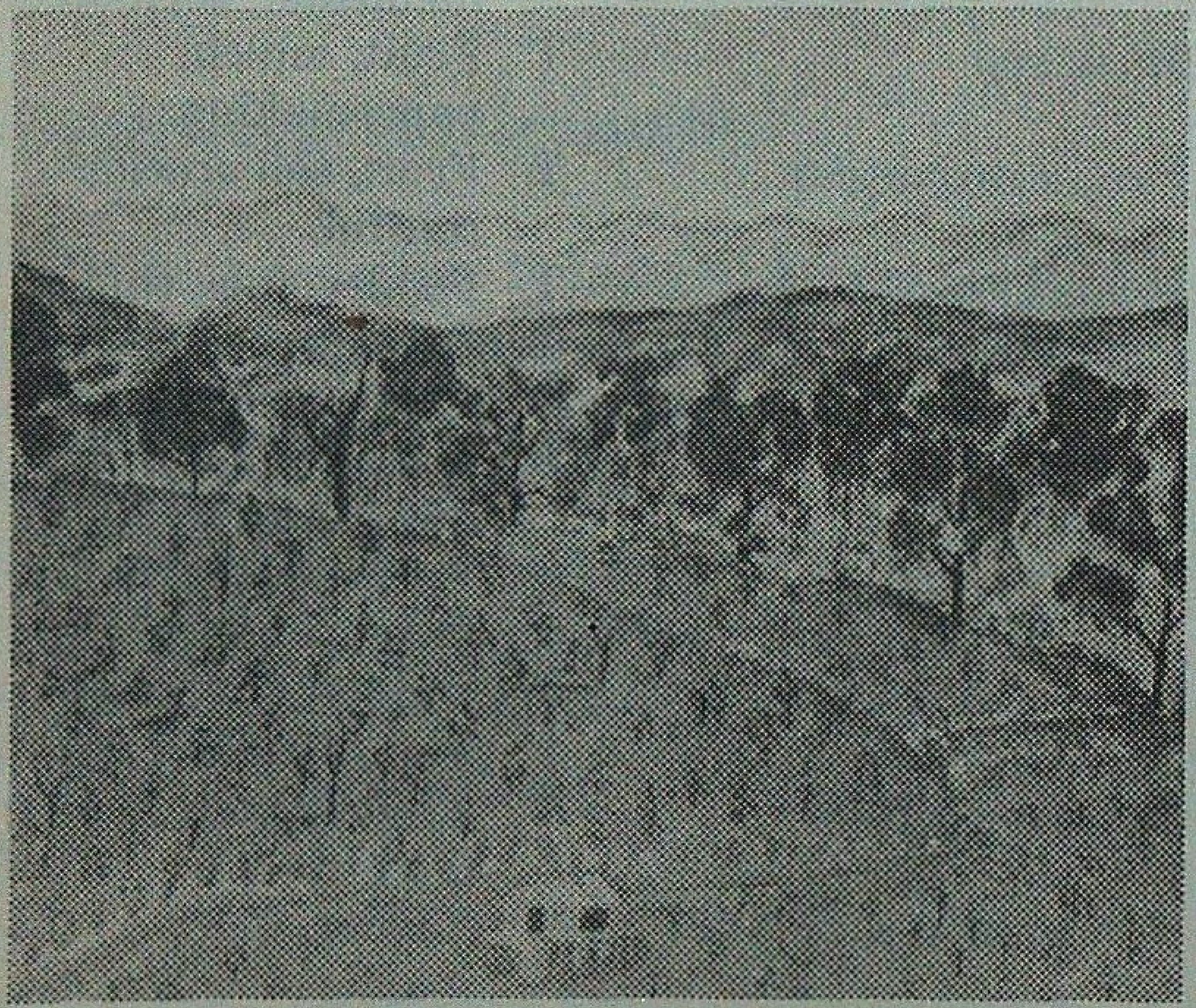
The most common and successful practice is intercropping of *Oryza sativa* (Paddy) along with *Tectona grandis* (Teak). The farmers remain engaged right from the felling of trees/shrubs, burning and removing of debris. Rice paddy is sown before the event of the first monsoon i.e. April-May, and stumps of teak seedlings are planted in the month of July. The paddy is usually harvested in November (Wet Rice Cultivation) and irrigable terrace cultivation harvests two crops a year. The landlords only share harvested crops with the farmers. (Table 4). The advantage of this system is that it decreases both the manual labour and the expenditure incurred in weeding.

Conclusion

Over the years, farmers of Mizoram have been practicing various forms of Agroforestry. They were getting benefits on sustained basis. Now they have started neglecting tree species in their farming system to grow maximum cash crop.

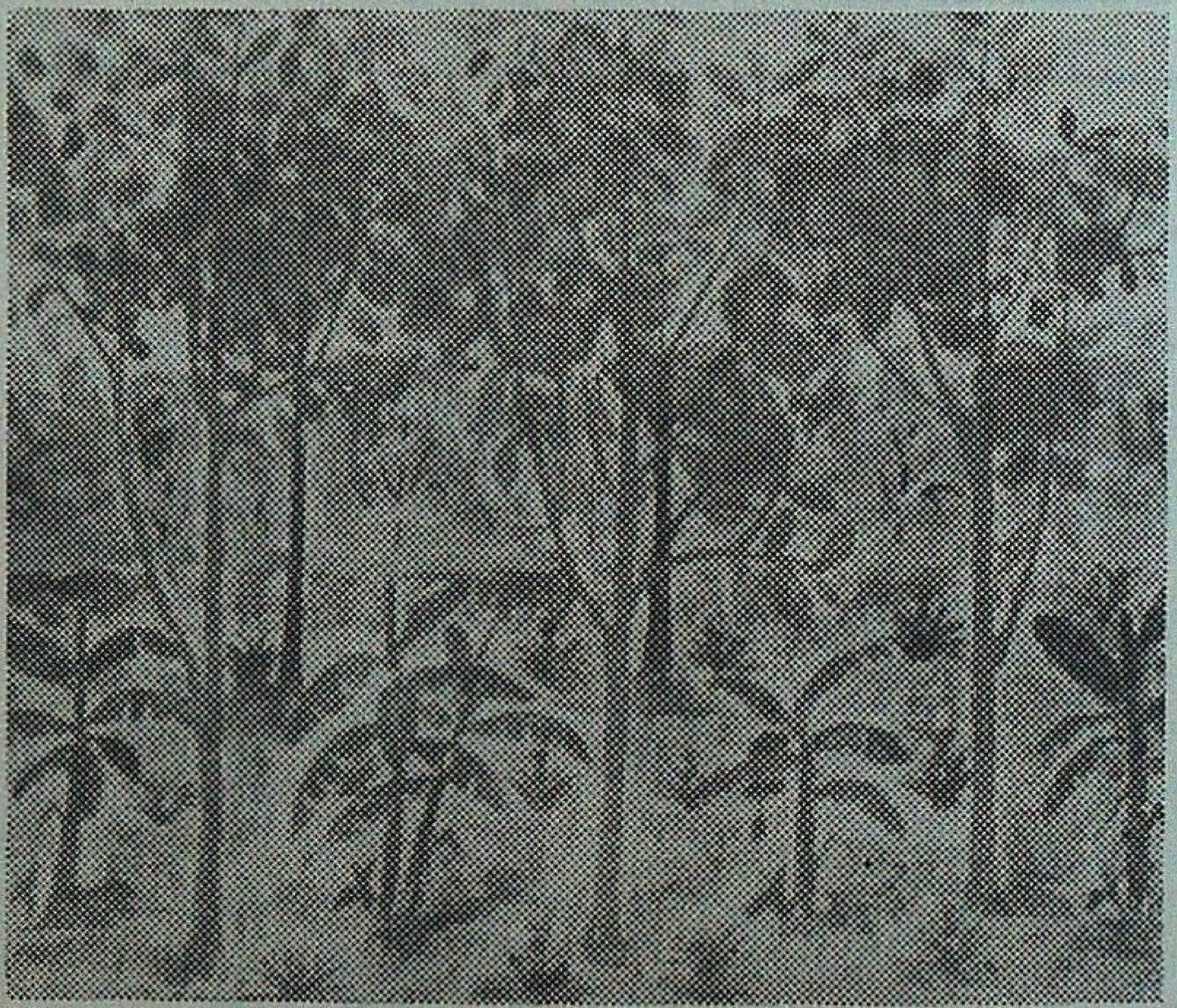
It is, therefore, urgent to innovate the land with new and non-traditional ways of agroforestry to derive sustainable benefits.

Fig. 1



A typical Mizo jhumland
Paddy and Teak

Fig. 2



An intercropping system of Ananas,
Musa sp. and Teak

Table 3

Prominent Agroforestry Systems and trees in Farming system of Mizoram

System	Combination			Tree density	Spacing (m)	Methods adopted
	Agri. crops	Horti crops	Trees			
Agri. + Trees	*Oryza sativa*	-	*Tectona grandis*	1925	2x3	Δ
	Zea mays	-	*Albizia procera*	722	4x4	Δ
	Zingiber officinale	-	*Anogeisus acuminata*	722	4x4	Δ
Agri. + Horti.	*Glycine max*	*Citrus reticulata*	-	2310	2.5x2.5	Δ
	Vigna sinensis	*Musa paradisiaca*	-	1284	3x3	Δ
	Capsicum annuum	*Pyrus persica*	-	834	3x4	–
Agri. + Horti. + Trees.	*Solanum melogena*	*Citrus sinenses*	*Mangifera indica*	400	5x5	☐
	Sesamum indicum	*Carica papaya*	*Aleurites fordii*	625	4x4	☐
	Solanum tuberosum	*Musa paradisica*	*Artocarpus Heterophyllus*	462	5x5	Δ
Trees + Horti.	-	*Citrus macroptera*	*Syzygium cumini*	834	3x4	–
	-	*Prunus communis*	*Cinnamomum obtusifolium*	578	4x5	Δ
	-	*Saccarum officinarum*	*Azadirachta indica*	400	5x5	☐
Multistoried homestead garden	*Ananus comosus*	*Coffea robusta*	*Mesua ferrea & Albizia chinensis*	400	5x5 & 278 6x6	☐&☐
	Ipomea batatas	*Citrus limon*	*Cassia fistula & Aporusa dioica*	400	5x5 & 400 5x5	☐& –
	Cymbopogon winteriana	*Areca catechu*	*Syzygium fruticosa & Parkia roxburghii*	625	4x4 & 278 6x6	☐&☐
	Arachis hypogea	*Manihot esculanta*	*Erythrina indica & Derris robusta*	578	4x5 & 385 5x6	Δ&Δ

Notes :

– Line planting method employed in gentle slopes areas.

Δ Triangular planting method employed in slopy areas.

☐ Square planting method employed in slopy areas.

Table 4

Yield of paddy and growth of Tectona grandis in Agroforestry in Mizoram

Location/Area	Crops	(1990-91) Ist yr (qtl/ha)	(1991-92) IInd yr (qtl/ha)	1992-93 IIIrd yr (qtl/ha)	Duration of days sowing to harvest	*Tectona grandis* (average height (m) after planting.			Remarks
						Ist yr.	IInd yr.	IIIrd yr.	
Aizawl'W' District	Bawngbu Kangpui Biruchuk	10.70	9.96	19.58	138	3.04	4.26	5.17	Improved Jhum cultivation with the help of fertilizers. viz, Urea DAP & MOP in the ratio of 60:40:40.
Aizawl'E' District	Bhuban Farate.	6.00	7.16	8.25	125	2.50	3.65	4.69	
Kolasib District	Bakite Farel Farelte	15.35	12.95	1.95	121	3.65	4.99	5.84	
Lunglei District	Bawngbuh Faratepui	13.60	18.00	22.00	108	4.13	5.49	6.69	
Chhimtuipui District	Liachai Jaka Kasaba IP-36 IR-36	6.40	8.00	4.33	149	2.74	4.04	5.05	

Notes : (1) The above crop yield is compiled from Experimental Plot No. I, II & III.
The total number of replicates in Plot No. I = 11 , No. II = 11 and No. III = 5.

(2) Plot No. I located at (1) Lengpui (402m) gentle slope, (2) Sateek (965m) steep-slopy, (3) Serkhan (1029m) hilly.
Plot No. II located at (1) Hauruang (677m) slopy, (2) Pachang (406m) low depression, (3) Lungeen (584m) gentle slope.
Plot No. III located at (1) Saihatlang (122m) hilly, (2) Maubawk (940m) slopy (3) Tuipang (1350m) hilly.

(3) Farmers are practicing continuous cropping system. They have not adhered to strictly with prescribed soil and water conservation methods. This is the main reason of decrease in productivity of crops at Aizawl 'E' District and Chhimtuipui District. Also the locations are more hilly-slopy than others.

Table 5

Location/Area	Initial spacing	Tree density	Crown density at IIIrd yr. (m)	Crown spread at IIIrd yr.
Aizawl 'W' District	2 x 3	1667	2.22	.5 and below
Aizawl 'E' District	2 x 3	1667	2.13	.5 and below
Kolasib District	2 x 2	2500	2.43	.5-.7
Lunglei District	2 x 2	2500	3.04	.5-.7
Chhimtuipui District	3 x 2	1667	2.13	.5 and below

SUMMARY

Mizoram is situated in the extreme South-eastern corner of North-East India. The affected area under slash and burn farming still bears hard on soil condition and ecology of Mizoram. However, over the years, peasants of Mizoram have been practicing various forms of agroforestry. A large number of multipurpose trees and shrubs(48 species recorded) are left deliberately or introduced in cropping system to increase the productivity. Govt. policy of promoting new farming technique, viz; Jhum Control Project - 1987 would have gone some way to relieve the compulsion of practicing Shifting Cultivation. The most common and successful practice is intercropping of *Oryza sativa* (Paddy) with *Tectona grandis* (Teak). This system is economically and ecologically sound.

मिजोरम की कृषि प्रणालियों में प्रमुख कृषिवानिकी प्रणालियाँ तथा महत्वपूर्ण बहुप्रयोन वृक्ष

जे०एच० लालरामनघिंगलोबे व एल०के० झा

सारांश

मिजोरम उत्तर-पूर्वी भारत के सबसे आखरी दक्षिण-पूर्वी कोने में स्थित है । काटो और जलाओ प्रणाली के अन्तर्गत आने वाले क्षेत्रों का अब भी मिजोरम की मृदा दशाओं और पारिस्थिकी पर भारी कुप्रभाव पड़ रहा है । तथापि पिछले कुछ वर्षों से मिजोरम के किसान कृषि-वानिकी के कुछ रूपों को अपनाए हुए हैं । उत्पादकता बढ़ाने के लिए बहुत सारे बहुप्रयोजन वृक्ष और क्षुप (48 जातियाँ बताई गई हैं) जानबूझ कर कृषि खेतों में छोड़ दिए जाते हैं अथवा बाहर से लाकर उगाए गए हैं । नई प्रविधियों को प्रोत्साहित करने की सरकार की नीति जैसे झूम नियन्त्रण परियोजना 1987 चल खेती करते रहने की मजबूरी कुछ सीमा तक कम कर सकती थी । इनमें सबसे सफल और आम प्रणाली धान (*ओरायजा सेटाइवा*) की खेती के साथ सागौन (*टैक्टोना ग्रांडिस*) रखने की है । यह प्रणाली अर्थतः और परिस्थितिविज्ञानतः ठीक है ।

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AGROFORESTRY SYSTEMS FOR MUSSOORIE HILLS IN WESTERN HIMALAYAS

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Introduction

In Himalayan region human and livestock population is about 3.50 million, and 4.25 million, respectively. Out of total 61.5 million ha land area there is only 17.80 million ha under forestry to meet the demands of fuel, fodder and timber (Bhatt, 1978). The Himalayan region which was once full of luxuriant forests with rich biodiversity is presently in dwindling phase due to large scale exploitation for fuelwood, fodder and timber by ever-increasing population. The forests surrounding habitations are dwindling at fast rate. The fodder scarcity is another concern in the region and most of the forest areas are subjected to over grazing and severe lopping. Tejwani (1987), Dadhwal *et al.* (1989), Mittal and Singh (1989), Singh *et al.* (1989), Toky *et al.* (1989), Khosla and Toky (1990), Nair and Dagar (1991) and many other have described agroforestry systems in Himalayan regions but little information is available about agroforestry systems of Mussoorie hills, therefore, the present work was undertaken.

Study Area

To evaluate the existing agroforestry systems to find out the adaptability of a particular type of system the present diagnostic and design survey was undertaken during 1988 in five villages namely Danio Kadanda, Makret, Khalagaon, Dhungalgaon, and Kiarkuli in Mussoorie hills (20^0 - 30^0 North latitude, 78^0 East longitude) located about 30 km away from Dehra Dun towards Mussoorie at an elevation of 1350 to 1625 m (msl). Five families from each village with different land holdings were selected for survey so that all types of agroforestry systems were represented. Area of the 80% of the families possessed land holding below 1 ha, 15% between 1.0 to 2.5 ha and 5% between 2.5 and 10 ha. The mean annual rainfall of the area is 1740 mm of which about 80% occurs during June to September. The mean daily maximum temperature is 20.7°C and mean minimum daily temperature is 6.6°C. The soils are generally well drained, silty loam with medium to high organic carbon, low in N & P and medium in K. The natural vegetation was predominated by shrubs and grasses. The most common species include *Boehmeria rugulosa, Grewia optiva, Lantana camara. Toona ciliata, Berberis asiatica, Cocculus laurifolius, Agave* sp., *Chrysopogon fulvus* and *Eulaliopsis binata*. The major crops being grown are maize (*Zea mays*) and lobia (*Vigna sinensis*) in kharif season and wheat (*Triticum sativam*), lentil (*Lens esculenta*) and barley (*Hordeum vulgare*) in rabi.

Table 1

Yield of crops (q/ha) from different crop sequences

Crop sequence	Yield q/ha	
	Ist Crop	IInd Crop
Maize - Wheat	10.77	10.42
Maize - Lentil	10.77	1.65
Mandua - Wheat	7.83	9.80
Maize - Barley	10.77	6.25
Fallow - Wheat	-	12.42
Mandua - Lentil	7.83	1.65
Lobia - Wheat	5.40	10.70

Traditional Agroforestry Systems

Over large areas the farmers adopt the following agroforestry systems :

Agri-silvicultural system : It is quite common throughout the region. Agricultural corps such as wheat, pulses, mustard, lentil and vegetables during the winter season, and maize, tomato, pepper, and other vegetables etc. during the summer season are grown in monoculture or polyculture on the permanent terraces. Multipurpose trees such as *Grewia optiva, Bombax ceiba, Toona ciliata, Celtis austrailis, Bauhinia variegata. Albizia chinensis* and *Morus serrata,* are deliberately grown on the bunds of terraces. The details of the tree with their main uses and lopped biomass is given in Table 2.

Agri-horticultural system : In this system the agricultural crops are mainly comprising rhizomatous or tuberous types of such as turmeric (*Curcuma domestica*) grown in the interspaces of horticultural trees such as peach (*Prunus persica*), apricot (*P. armeniaca*) and plum (*P. domestica*). In this system the yield of turmeric could be 3.8 to 4.2 t ha^{-1} and of peach, apricot and plum on an average 12, 10 and 24 kg per tree, respectively.

Table 2

Multipurpose tree species in agri-silviculture systems.

Species	Lopped biomass	Density no/ha	Average height (m)	Main uses
Grewia optiva	12.15	608	5.2	Fodder, fuel, timber
Grevillea robusta	20.25	43	6.6	Fodder, fuel, avenue timber
Bombax ceiba	30.35	21	6.9	Fodder, timber, fuel,
Boehmerica rugulosa	20.30	54	5.7	Fodder, fuel
Toona ciliata	25.30	62	7.5	Fodder, fuel, small timber
Celtis australis	30.40	31	8.8	Fodder, fuel, small timber
Ficus roxburghii	25.30	26	3.9	Fodder, fuel, small timber
Bauhinia variegata	15.20	13	4.5	Fodder, fuel, vegetable
Albizia chinensis	20.30	11	9.6	Fodder, timber, fuel
Morus serrata	40.50	24	3.4	Fodder, fuel, fruit
Cocculus laurifoilus	20.25	14	2.3	Fodder, fuel
Syzygium cuminii	5.10	16	10.5	Fodder, fruit, fuel
Dendrocalamas sp.	15.20	12	5.3	Bamboo, timber
Melia azedarach	12.15	23	5.8	Fodder, fuel, timber medicine
Others		27	6.2	Fodder, fuel, medicine

Agri-horti-silvicultural system : This system involves the production of grains or cereal crops as the main agricultural crops and fruits such as citrus, apple and banana, and also the trees much needed for fodder, fuel and packing material. In one observation besides getting 4 tonnes of turmeric, 6 tonnes of fodder, 3 tonnes of fuel, 2 tonnes of timber wood and 8 tonnes of fruits ha^{-1} were obtained. This system needs more attention, labour and fertilizers to get optimum yield.

Silvi-pastoral system : This is most common traditional system found in hilly regions. The cattle graze in forest lands or on open pastures predominated by wild grasses such as *Chrysopogon fulvus, Heteropogon contortus, Eualiopsis binata* and *Dichanthium annulatum.* These grasslands are low in their biomass production. The fodder trees are lopped frequently particularly during lean period but still do not meet the required needs (Table 3). In another observation tree components could give 9 q of boles, 195 q of fire wood and 26 q of fodder leaves ha^{-1} every year and grasses could contribute about 40 q ha^{-1}.

Homesteads : This is most widely distributed traditional system found in every village. The fruit trees and forest tree species are common along homesteads to meet the daily needs. The yield of some fruit trees are given in Table 4.

Though there is enough potentiality of getting good crops and a variety of other essential componenets such as fodder, fuel, small timber and fruits to sustain the economy of the farmers but there are many constraints due to which optimum exploitation is not possible.

It is obvious from present survey, that the productivity and economic yield under agri-silvi-horticultural system was

Table 3

Fodder requirement and its production

Fodder	Total requirement (t)	Source of availability		Purchased from market (t)
		Own land	Panchayat land	
Straw (Dry)	77.3	42.6	Nil	34.7
Leaves (Lopped biomass)	89.2	17.8	71.3	Nil
Grasses (Forage)	182.7	73.0	109.5	Nil

Table 4

Average annual yield from horticultural crops during 1988.

Fruits	No. of plants (around homestead)	Average yield (kg/plant/yr.)	Total yield (q/yr.)
Citrus (*Citrus* sp.)	68	16	10.9
Banana (*Musa paradisica*)	36	20	7.2
Akhrot (*Prunus armeniaca*)	110	8	8.8
Peach (*P. persica*)	200	12	24.0
Plum (*P. domestica*)	110	25	27.5

maximum and this system is more sustainable and socially and economically acceptable, provided good technologies are evolved and farmers are trained to adopt these. On hilly region another feasible sustainable system is silvi-pastoral system through which we may meet the demand of fodder for ever increasing population of cattle. In this system we would have to control overgrazing. Recent techniques of alley cropping on hilly sloping lands are to be followed when arable corps are grown in the interspaces between rows of fruit trees or other woody perennials. In this system besides getting fodder, fuel and wood, the soil erosion will be controlled and if leguminous woody perennials are grown as alleys, the soil fertility will be enhanced or maintain.

The importance of agroforestry in hilly region is more than the plains particularly on the community lands. Raising small timber woodlots of multipurpose trees and fruit based cottage industries may help in improving the socio-economic status of the rural poor people. To meet the need of wood for packing cases, the trees of softwood would have to be blended with horticultural trees and the community lands may be brought under improved variety of grasses blended with fodder and timber trees. This will also help in releasing the pressure on forests.

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SUMMARY

The Himalayan region which was once full of luxuriant forests with rich diversity of species is presently dwindling at fast rate due to large scale exploitation for fuelwood, fodder, timber and packing cases. The demand for these commodities may accomplished through agroforestry systems well blended with multipurpose forest tree species, horticultural tree species and crops or grasses. There is wide scope of silvi-pastural systems after closing the pastures from grazing. Results of a survey related to existing agroforestry systems along with various constraints and the adaptability of agroforestry systems have been discussed. Economic yield and productivity from agri-silvi-horticultural systems was maximum as compared to other agroforestry systems.

पश्चिमी हिमालय प्रदेश में मसूरी पहाड़ियों के लिए कृषिवानिकी प्रणालियाँ

वी०पी० सिंह व जे०सी० डागर

सारांश

हिमालय प्रदेश जो कभी सुसम्पन जाति-विविधता वाले हरे-भरे जंगलों से परिपूर्ण था अब ईंधनकाष्ठ , चारा और पेटियों का उत्पादन करने के लिए बड़े परिमाण पर समुपयोजित किया जाने के कारण बहुत तेजी से हरियाली विहीन होता जा रहा है । इन वस्तुओं की मांग को कृषिवानिकी प्रणालियों द्वारा, जिनमें बहुप्रयोजन वन वृक्ष जातियों, बागबानी की वृक्ष जातियों और फसलों अथवा घासों को भलीभांति मिलाया हुआ हौ, काफी अच्छी तरह से पूरा किया जा सकता है । गोचर क्षेत्रों में चराई बन्द करने के बाद उनमें वन-गोचर प्रणाली चलाने की काफी गुंजाईश है । प्रस्तुत अभिपत्र में वर्तमान कृषिवानिकी प्रणालियों से संबंधित एक सर्वेक्षण का और उसके साथ विभिन्न कठिनाईयों तथा कृषिवानिकी प्रणालियों की अनुकूलनीयता का विवेचन किया गया है । अन्य सभी कृषिवानिकी प्रणालियों की तुलना में कृषि-वन-बागवानी प्रणालियों से मिलने वाली आर्थिक प्राप्ति और उत्पादकता अधिकतम पाई गई ।

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AGROFORESTRY IN PUNJAB – CURRENT STATUS AND CHALLENGES

JITENDRA SHARMA*

Introduction

Punjab is an agrarian State which boasts of highest contribution of surplus Agricultural produce to the Central Government's Pool.

Over a period of time, the State has also come to acquire another distinction - it is one of the few States which are said to be surplus in fuel and fodder production. The State is exporting wood to the highly forest-rich States like Himachal Pradesh.

The Natural Resource Setting

The geographic area of the State is 50362 km^2. The average annual rainfall ranges from 400-600 mm and the average annual temperature ranges between 22.5^{0}C to 25^{0}C. As per Social and Economic Atlas of India (Muthiah, 1987) the seasonal temperature variation is quite extreme and ranges from a maximum of 45^{0}C in summer to even upto 0^{0}C minimum in winters. Further, the groundwater potential of the State is estimated to be about 1.5 million hectare metres per year, which is below the estimated total groundwater potential of a large number of States. However both surface irrigation as well as tubewell irrigation in Punjab are very intensely developed. As a consequence the percentage of utilisation of groundwater potential is amongst the highest in the country.

The Principal Physical Divisions

The principal physical divisions of the State include :

(i) The Sub-Himalayan Region (locally referred to as the 'Kandi Tract') and
(ii) The Plains.

The former has immature mountain soils and the latter has alluvial soils with pockets of sand - especially in the South-Western Districts of the State.

According to the Forest Survey of India (Anon., 1995), four out of the twenty agro-ecological regions of India are represented in Punjab. They are as follows :

(1) *Western Himalayas, warm sub-humid eco-region* : It lies all along the North-Eastern bordering strip of the State that runs parallel to the Himachal Pradesh boundary in the form of 'Kandi tract'. It contains a major portion of the State's naturally occurring block forests and it runs through the Districts of Gurdaspur, Hoshiarpur and Roopnagar. The last two are the only districts in the State with a forest cover of over 15% (Anon., 1995).

(2) *Northern Plain, hot sub-humid (dry) eco-region* : It is a parallel belt to the above region, running into the central districts of the State.

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(3) *Northern Plain and Central Highlands* : It lies next to the above eco-region and has a shorter growing period.

(4) *Western Plain, hot arid region* : It has the smallest growing period of less than ninety days, and it lies in the South-Western extremity of the State.

The sharp difference between the last three ecoregions has been rather blunted due to intensive land management and because of availability of assured irrigation. This has considerably enhanced the productive capacity of the agricultural lands - atleast for the time being.

At present, only 5.2% of Punjab's geographic area is recorded to be under forest cover. Its per capital recorded forest area at 0.01 hectare, is among the lowest in the country. Thus a relatively high quantum of wood production in Punjab, has been made possible by the unitiring efforts of the enterprising farmer of Punjab who has taken upon himself the task of planting trees on a large scale under different Agroforestry systems.

The Agroforestry species of Punjab

As per the information collected from the State Forest Department, the following planting material was distributed under Farm Forestry scheme for plantation on non-forest lands as given in Table 1.

The above data clearly indicates an uptrend in offtake of *Eucalyptus* and Poplar the two main species that have brought about transformation of landscape of the Punjab countryside. They are most popular because of least interference with agricultural crops because of their crown structure and other favourable silvicultural characteristics.

Table 1

Number of plants supplied by Forest Department, Punjab.

Species	Year		
	1992-93	1993-94	1994-95
Dalbergia sissoo	82,842	1,03,500	2,28,591
Acacia nilotica	10,80,140	3,25,794	2,66,483
Eucalyptus	3,77,586	5,01,968	6,93,218
Acacia catechu	1,41,651	32,450	87,208
Leucaena leucocephala	69,351	14,350	1,560
Albizia lebbek	70,562	97,185	18,105
Populus deltoides (including cuttings)	12,05,126	15,07,799	16,89,959
Melia azedarach	1,04,069	40,130	54,625
Holoptelia integrifolia	31,851	14,000	6,200
Others	49,46,822	19,99,824	15,63,051
Total	81,10,000	46,37,000	46,09,000

Eucalyptus : *Eucalyptus* (mainly *Eucalyptus* hybrid) was the first one to be adopted by the farmers. The *Eucalyptus* wave started taking a shape through extension efforts of Punjab Forest Department in the late sixties and the early seventies. It gradually gained momentum in all parts of Punjab as farmers, in general, experienced no adverse ecological effects of *Eucalyptus* plantation inspite of doomsday scenario that was painted before them by some environmental lobbies throughout the seventies and the eighties.

However, after the mid-eighties, *Eucalyptus* plantation as well as the Punjab farmer, suffered a serious set back and many small farmers out of disenchantment and discontentment started uprooting from their agriculture fields. This was not because of any adverse ecological effects of adopting

Eucalyptus but because of the economic setback the farmers received through meager prices obtained after harvesting crop. The price went as low as between Rs. 20 to 30 per quintal of wood (Green wood weighs about 14 quintals per CMT). This was far lower than the returns projected or the returns that were obtained by farmers who harvested in the earlier years.

It resulted in virtually no plantations of *Eucalyptus* being taken up the farmers. This state of affairs continued till the early nineties.

The reasons for this glut were not difficult to see. They were :

1. An inefficient market, with imperfect competition, almost always dominated by middle men.
2. Excess of supply in the markets due to maturing of a large number of plantations at the sametime.
3. Deteriorating law and order situation of the State in the recent past resulted in non-establishment of *Eucalyptus* based paper and pulp mills in the State.
4. In plantations which observed very close spacing the trees did not put sufficient increment and hence fetched far less returns than that were expected by the farmers at the time of planting.

The Current Scenario : However, of late, the use of *Eucalyptus* as a popular species in agroforestry plantations has bounced back in Punjab due to the improved market conditions. The market price being obtained today is a far cry from the prices that the farmers were obtaining in the late eighties for their produce. Some of the factors responsible for this turn about were :

(i) Opening up of new market avenues like use of *Eucalyptus* in packing cases for Himachal Pradesh apple crop in a big way.

(ii) Market intervention in the early nineties by the Punjab State Forest Development Corporation Ltd., which started procuring debarked *Eucalyptus* from farmers and supplied it to paper mills in Uttar Pradesh. This helped in stirring up the competition in the market and giving a fillip to the depressed prices which continued to rise thereafter.

(iii) Revival of market for the *Eucalyptus* crates and increasing use of this wood in furniture making and even house construction activities.

Thus damning judgments passed on *Eucalyptus* as a species unsuitable for Agroforestry, and being "The God that failed", have not been proved to be correct.

Poplars in Agroforestry

The depression of *Eucalyptus* market prices in the eighties gave a fillip to the interest of farmers, especially the large farmers to begin with, in Poplar plantations under Agroforestry system. Though a more demanding species than *Eucalyptus* in terms of management inputs, returns from Poplar plantations were higher compared to the *Eucalyptus*. So large scale plantations of *Populus deltoides* were raised, especially on irrigated fertile, well drained soils in different parts of the State G-3, G-48 and D-121 are some of the more popular clones which have shown very high productivity.

Further the Wood-based private industries have also played a key role in promoting poplars in agroforestry. WIMCO, with help the of NABARD, has taken a lead in supplying quality propagation material, loan, technical back up and by-back facilities for Poplar to the farmers of Punjab.

Seven years back, on similar lines, a scheme was launched by Punjab Forest Department and the Punjab State Co-operative Agricultural Development Bank Ltd. to support efforts of Punjab farmers in raising Poplar in their fields.

Good quality planting material and technical support to the farmers was offered the Forest Department, while the loan was given by the Bank.

This scheme provided propagation material as well as technical support to the farmer much cheaper than the WIMCO did, but the scheme did not offer a buy back support price unlike the WIMCO scheme. The following other useful lessons can be drawn from the experience of implementation of this scheme.

(i) Quality of supervision by the Forest Department suffered because no extra extension staff was provided to the Department to run the scheme in more purposeful manner.

(ii) For some period Forest Extension Ranges were created from within the existing forestry staff, but often without any adequate supporting infrastructure. The staff which was not particularly interested in the extension work and often the staff that was perceived to be unfit for Territorial Ranges, was posted to man these ranges. No provisions were made for special training in extension methodology to these officials and no concrete special measures to raise their motivation level could be taken. Hence quality of implementation suffered.

(iii) Many subsequent field inspections of the farmers plantations by the Forest Department Staff showed that many farmers had not taken due care of the plants. Many of hem, it appeared, were more interested in obtaining the loan, in same cases, perhaps with a hope that at some point of time political compulsions would help them to get their loans subsequently written off, as had been the case in many other agricultural schemes in the past.

Recent inquiries have revealed that the demand for Poplar planting material is currently more than what is being raised by in the Forest Department Nurseries. One of the reasons for shortage of good quality nursery stock probably is that in Forest Department targets for raising Poplar nursery stock are conveyed in April while the planting season in nurseries is over by February itself.

Market Rates

(i) *Eucalyptus* : Inquiries during May 1996 at Hoshiarpur have revealed a continuing uptrend in the market prices of *Eucalyptus*. Round logs 45-75 cm mid girth are selling around Rs. 115 per quintal (approximately Rs. 6000 per CMT) while good quality mature logs of more than 75 cm mid girth are marketed upto Rs. 2100/- per CMT.

(ii) *Poplar* : Poplar wood sells on an average at Rs. 2,500/- per CMT. But good quality mature logs are fetching even higher price.

Thus the returns from Agroforestry have again started becoming lucrative for the farmers. This is very significant as agroforestry plantations in Punjab are largely market driven rather being subsistence driven.

Deficiency, Disease and Agroforestry Crops

Zinc deficiency is becoming increasingly common in many Districts of Punjab. Deficiency of other micro-nutrients like iron, magnesium, calcium, copper, born and molybdenum is also now getting common.

A result of micro-nutrient deficiency is less vigorous plants. Even die-back is becoming very common. In case of *Eucalyptus* die back is thought to be result of micro-nutrient deficiency coupled with pathogen infestation of bacteria and even mycoplasmas.

Therefore, there is an urgent need for a systematic disease status survey to deal with this problem comprehensively, otherwise things way go out of hand in near future.

Poplars are also infested often after 3rd year, by termites, mites, leaf defoliators, stem and shoot borers. It requires intensive management on this account. Gaumexene, dimethoate, endosulfan and fumigation, followed by bordeaux paste application have been found useful in case of termites, mites, Defoliators and borers, respectively.

Wheat, sugarcane, fodder crops, turmeric pulses and even vegetables have been successfully intercropped with Poplar during the first few years. The common planting spacing followed between rows is 5 metres apart, in channels for irrigation.

Future Issues, concerns and challenges

The following emerge as the focal points for long term management of Agroforestry in Punjab :

(1) *Market Intelligence* : It is imperative to develop sound system of Market intelligence for the tree species so that the farmers can make informed choices in tree plantation.

(2) *Provenance trials* : Such trails need to be done for a larger number of taxa to provide a wider choice to the farmers.

(3) *Extension activity* : Extension Wing of the Forest Department needs to be greatly strengthened in order to have a close rapport with the farmer, and give him timely support.

(4) *New species* : Their is an urgent need to do trials on agroforestry models involving potentially attractive species like Teak and Bamboo. Infact Bamboo clump planting along agricultural fields is already quite popular in pockets of Punjab, e.g., as along the banks of Ravi in District Gurdaspur. The Forest Department can take up more such plantations to demonstrate their viability and economic returns to the farmer.

(5) *Right Growth data* : It is important that growth data of row plantations may not be used for projecting growth/returns for block plantation as the yields in the two models may be quite different.

(6) *Spacing* : Their is a need for special extension effort to prevent farmers from planting at a very close spacing.

(7) *Disease Surveys* : Their is a need for carrying out systematic disease survey of the agroforestry species as such diseases have already appeared and may take shape of an epidemic in the future.

(8) *Quality Germplasm* (i) Often the germplasm material supplied to the farmer is not necessarily the best. This greatly

effects the yield from such plantations and all estimates can go haywire if the germplasm is taken from any source and randomly distributed. (ii) There is a need to establish quality seed orchards/germplasm banks.

(9) *Research* : The Research Directorate of the Forest Department will have to be strengthened greatly to provide quality services to the farmer.

(10) *Market Linkages* : As a part of forward linkages large scale wood-based industry, to add value to the farmer's raw material, will have to be encouraged and established within the State. Otherwise the farmer will be at the mercy of the market middlemen and no amount of good work done by the Forest Department can get the farmers the true reward for their labour invested in agroforestry plantations.

SUMMARY

This paper brings forth the natural resource setting and some of the socio-economic factors that influence the Agroforestry practices in the State of Punjab. It also explores the role of the Forest Department, Wood-based Industries and the Banks in promoting Agroforestry in the State; bringing out the lessons learnt in implementation of various Agroforestry schemes. It also traces the ups and downs in adoption of Agroforestry species - especially *Eucalyptus* and Poplar - by the farmers in Punjab. The paper pinpoints the issues and challenges before the Forest Department in sustaining the momentum of Agroforestry in the State.

पंजाब में कृषिवानिकी - वर्तमान परिस्थिति एवं चुनौती

जितेन्द्र शर्मा

सारांश

इस अभिपत्र में पंजाब राज्य की प्राकृतिक सम्पदा योजना तथा कुछ सामाजिक नियोंगो तथा कृषिवानिकी के आचरण पर प्रकाश डाला गया है । राज्य में वन विभाग, काष्ठ आधारित व्यवसाय तथा बैंकों की भूमिका व कृषिवानिकी की कई प्रभावशाली योजनाओं के विषय को भी खोजा गया है । पंजाब में कृषकों द्वारा अपनाई गई कृषिवानिकी वृक्ष जाति मुख्यतः *युकेलिप्टस* तथा पोपलर के परिणामों को खोजा गया है । राज्य में वन विभाग के समक्ष कृषिवानिकी की सतत गति की चुनौती को सूक्ष्मता से आंका गया है ।

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AGROFORESTRY PRACTICES IN HILL FARMING OF SIKKIM

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Introduction

Sikkim is the smallest State of Himalayan range of India in the east and has an area of 7096m^2. It has a high montane type of climate which varies from subtropical to alpine depending upon the elevations. It receives heavy rainfall due to direct exposure of Bay of Bengal and high mountain acts as a barrier to the south-east monsoon. The mean annual rainfall varies from 2000 mm to 5000 mm/annum with intensity of raining from drizzling to torrential rains. Temperature varies with elevation and slope aspects. Three soil temperature classes have been identified; Thermic, Mesic and Isofrigid. Throughout the year relative humidity remains above 70 per cent at most places of Sikkim. There are five climatic zones in Sikkim resulted from elevation variations (300 - 8500 m above msl). These are Warm Tropical (upto 800 m), Subtropical (900-1800 m), Temperate (1800-3500 m), Alpine and Subalpine (3000-4500 m) and Stony Deserts (above 4000 m) (Khoshoo, 1992). Thus there exists great deal of biological diversity in comparatively small area. Teesta is the main river and with its tributaries drains the catchment of Sikkim and divides the State into two parts while flowing from north to south.

The variation of elevations with high rainfall and different temperature rigimes allow the cultivation of many types of crops (upto 2000m mainly) on naturally developed soils and undulated topography. The existing land use pattern in Sikkim indicates that more than one third land is under forest, 14% under cultivation, 28% barren and uncultivable land and 14% under pastures and grassland including alpine and subalpine scrubs and cultivable wasteland. The economy of State is primarily based on agriculture, 89% population sustains livelihood from farming. The hill farming system is largely self contained, with land, livestock and people being well interconnected. The uncultivated forest land provides the villagers for their supply of fuel, fodder, timber, medicine, water source, animal bedding and forest litter for compost making and mulch to ginger cultivation. The traditional agricultural systems in the different climatic zones of Sikkim have evolved over a long time scale within the historic period. The various catenary landscape systems in Sikkim has been closely linked with varying components of agriculture. Bhutia and Lepcha of original inhabitants of Sikkim take large (*Amomum subulatum* Roxb.) in combination with trees on steeply slopy lands at an altitude between 600 and 2000 m since time immemorial. Farmers grow multipurpose trees and intercrops with vegetables, and cereals near their homestead which meet their requirement of food, fruit, fuel, fodder and vegetable. Almost they intercrop the fruit orchards (mainly mandarin, *Citrus reticulata* Blanco) with maize, ginger, vegetables, pulses and oil-seeds by supplying organic manure to the orchards. Fodder tree are also integral part of their agricultural systems which provide the feed to the livestock in the scarcity period (winter). A simplified schematic model of traditional hill farming system is presented in Fig.1.

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General Description

Vegetation : The physiography coupled with precipitation, temperature and altitude is ecologically and geographically highly diversified and floristically also richest among the world. The tropical evergreen forest occurs in the foothill at an altitude of 800m. Subtropical forests are found between 900 to 1800 m characterized by *Schima-Castanopsis - Engelhardtia - Saurauia* association in higher altitudes and *Ficus-Castanopis-Cellicarpa* association in the lower reaches (Khoshoo, 1992). The temperate forests consist of evergreen oak forest at an altitude of 1800-3000 m and temperate coniferous forests (2800-3500 m). The subalpine zone (3000-4500 m) is practically the region of the *Rhododendron* and pine forests. Vegetation altogether disappears at an about 4000 m depending upon exposure and proximity to snow peaks and glaciers.

Geology : The important groups of rocks have been recorded in the State consist mainly Daling, Darjeeling and Gondwana groups. The North-Central part of the West Sikkim is chiefly made up of Darjeeling gneiss. The Daling group is found in the central part of the Sikkim has a very complex character and is composed of phyllites, schists, slates and quartzites. The younger Gondwana contains sand-stone, shale, carbonaceous shale with occasional thin coal bands. The North, Eastern and Western portion of the State is made up of hard massive gneiss rocks which are comparatively more resistant to denudation.

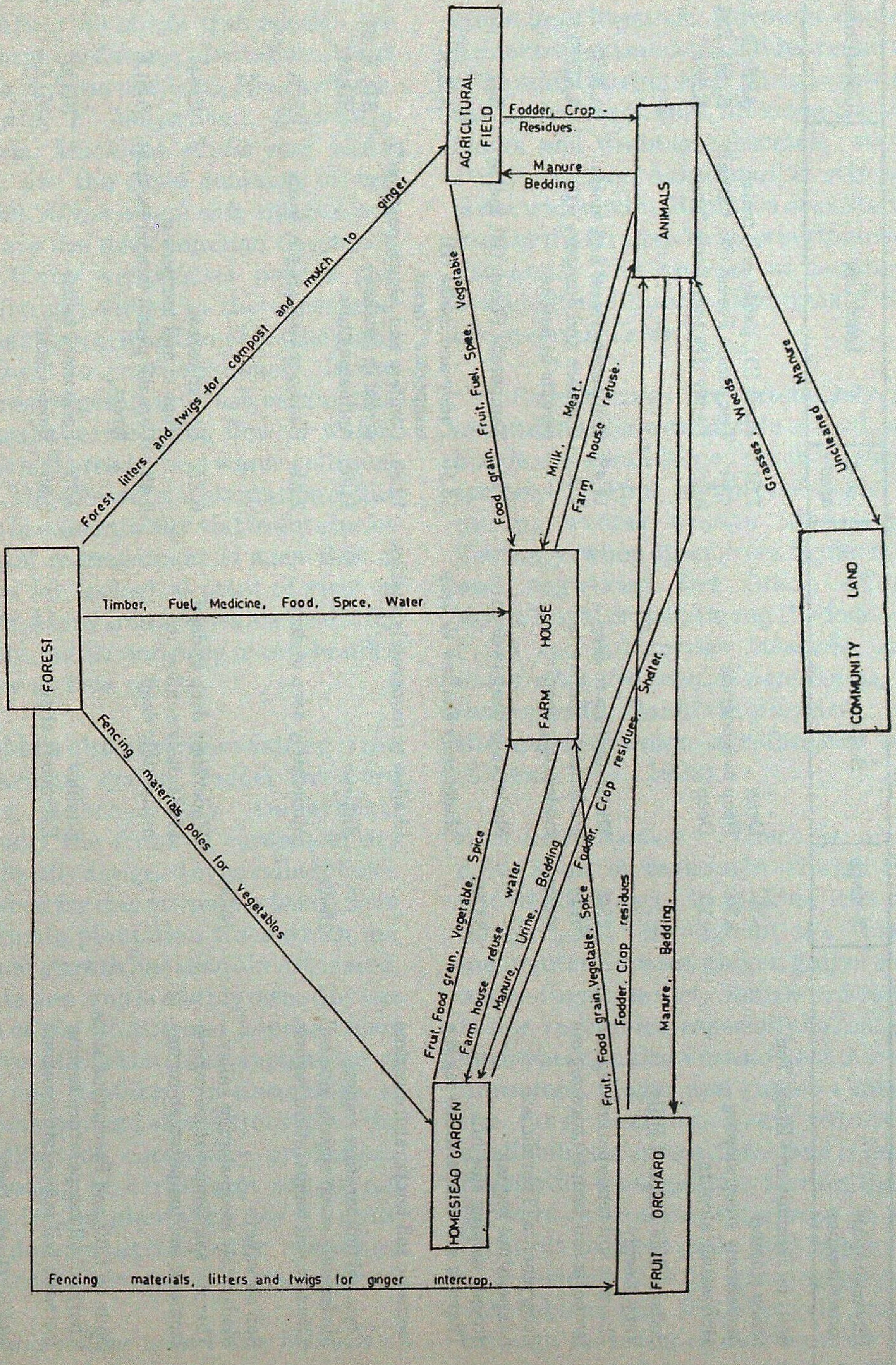
Soil : The soils of Sikkim broadly grouped into 5 physiographic zones are given in Table 1 with their characteristics. Soil erosion is one of the major cause of soil degradation on steeply slopy lands and often subjected to land slides or land slip. The soils of Sikkim belong to 3 soil orders of Inceptisols (33.4%), Entisols (43%) and Mollisols (29.6%) and 12 great subgroups (Anon., 1992). The depth of soil at different places varies considerably because of differences in physiographic position and slope. The fertility of soil also depends much on the geological formation of the underlying rocks.

Current Practices of Agroforestry

In Sikkim agroforestry is an integral part of the farming, where trees are integrated extensively with crop and livestock production systems. At higher altitude, the inhabitants entirely depend on grazing animals like Yak, Himalayan goat and wild life. The principal crop are grown maize, rice, millet, wheat, barley, rice-bean, soyabean, large cardamom, orange, potato, buckwheat etc. upto 2000 m elevation on slopy lands. Terrace system is the most prevailing type of rice cultivation. Maize, oat and buck wheat in grown even upto the heights of 3000m. Crop husbandary is dependent both on forestry and livestock. The most prevalent agroforestry systems of Sikkim hill are described briefly.

Plantation crop combination : *Amomum subulatum* Roxb. is a native plant of Sikkim cultivated since time immemorial under the shade of trees on hill slopes more than 35%. It grows well from 600-1500 m where mean annual rainfall varies from 1500-

Fig. 1


FOREST
AGRICLTURAL FIELD
ANIMALS
FARM HOUSE
COMMUNITY LAND
HOMESTEAD GARDEN
FRUIT ORCHARD
Forest litters and twigs for compost and mulch to ginger
Fodder, Crop - Residues.
Manure Bedding
Timber, Fuel, Medicine, Food, Spice, Water
Food grain, Fruit, Fuel, Spice, Vegetable
Milk, Meat.
Farm house refuse.
Grasses, Weeds
Uncleaned Manure
Fencing materials, poles for vegetables
Fruit, Food grain, Vegetable, Spice
Farm house refuse water
Manure, Urine, Bedding
Fodder, Crop residues, Shelter.
Fruit, Food grain, Vegetable, Spice
Fodder, Crop residues
Manure, Bedding.
Fencing materials, litters and twigs for ginger intercrop.

Principal interacting components in different Agroforestry systems of Sikkim

Table 1

Physiographic classification of Sikkia soils (Anon., 1992)

	Physiographic zone/subzones	% slope	Soil depth	Geog. area	Land Use	Constraints
1.	Soils on Summit and Ridge Top					
	Steep sloping	>30	Deep	1.61	Forst (D), paddy and maize	APE, Ct, SA
	Moderately steep sloping	<30	Deep to moderate	2.61	Temperate Forest (D), Cereals	E, SD, SSt
	Moderately sloping	<15	Deep	0.28	Paddy (D), temperate forest	E,SSt
2.	Soils of Side Slope of Hills					
	Very steeply	>50				
	Thermic soil temerpature regime	<50	Miderate deep to deep	14.43	Temperate forest and maize	A,E,St
	Isomesic soil temperature regime	Very steep	Moderately shallow to moderately deep	4.59	Conifers and Junipers (D) cereals in patches	A,SD,St,E
	Escarpments (Thermic soil temperature regime)		Moderately deep to deep	5.76	Temperate Forest (D), maize	E,A,
	Steeply sloping side hill	33-50				
	Thermic soil temperature regime		Moderately shallow to deep	13.50	Paddy and maize (D) temperate Forest	A,E,St
	Isomesic soil temperature regime		Shallow to moderately shallow	12.83	Conifers and Alpine pasture(D) cereal in patches	SD, E, St
	Cryic sol temperature regime		Shallow	11.06	Apline pasture	SD,St
	Moderately steep sloping side hill	15-30				
	Thermic soil temperature regime		Moderately deep to deep	2.21	Paddy, maize, ginger, fruits	E, A
3.	Soil on valleys					
	Moderately steep sloping valley	15-30				
	Thermic soil temperature regime		Moderately deep to deep	0.77	Forest, cereal tropical and temperate	E, St
	Isomesic soil temperature regime		Moderately shallow to moderately deep	0.45	Cereals, potao, temperate fruit, forest	A,St,E
4.	Soils on Cliff and Precipitous slope					
	Thermic soil temperature regime		Shallow	2.35	Permanent fallow	SD,E
	Isomesic soil temperature regime		Extremely shallow	9.85	Barren land	SD,E
5.	Soil on Glacial Drift					
	Moraines and Boulders					
	Isomesic soil temperature regime		Moraines and boulders	3.59	Forest	SD, St, E

(D)= Dominant, APE = Active potential erosion, Ct = Coarse texture, SD = Soil depth, S = Surface, St = Stoniness, A = Acidity, Geo. = Geographical

3500m/year and temperature between 6°C to 33°C. About 30 shade tree species are found in large cardamom plantation. *Alnus nepalensis, Schima wallichii, Measa chesia, Ficus cunia, F. benjamina, Saurauia napaulensis, Machilus edulis* and *Melia composita* are the most common (Singh *et al.*, 1989). *Alnus nepalensis* and *Schima wallichii* are the most common deciduous species. *Alnus nepalensis* posses the nitrogen fixing nodules on the superficial roots in the clumps, which enables the plant bearing them to grow vigorously. Dense ground forest vegetation (grass, cardamom, herbs, shrubs) arrests the flow of water, reduce the soil erosion and water pollution hazarads. The commercial plantation of this spice crop is economically viable enterprise and the soil management is such that is fairly good for ecological point of view on slopy lands. Many tree species are useful for timber, fuel, fodder and drug plants besides their value as food plants.

At middle altitude where dairing is the part of farming system, fodder trees are becoming increasingly important. Traditionally the fruits of cardomom are dried in a locally designed oven called *bhatti*. The fuelwood for this purpose is taken from the cardamom plantation trees which are old and their growth has been almost ceased. This plantation crop is mainly owned by the members of the Bhutia and Lepcha tribes inhabitants of Sikkim. The application of manures and fertilizers in uncommon in large cardamom and shade trees have the positive effect on cardamom production. After planting of cardamum soil is not disturbed in the plantation. As a result, large cardamom agroforestry resembles natural forest ecosystem to a great extent.

Bamboo and fodder trees : The farmers of Sikkim by and large adopt the mixed farming system comprising of agricultural crops and livestock. Farmers depend on fodder trees to meet the fodder requirement of animals during lean period (winter). In the agricultural field, all along the stream banks and drainage channels, stands of *Dendrocalamus hamiltonii, D. sikkimensis* is not uncommon. Bamboos are extensively used by the farmers for meeting their various demands. The species of bamboo are available at different elevations of Sikkim are given in Table 2.

Fodder trees are extensively grown around the homestead, side of road, on field bunds and small stoney patches among the terraces. Partial lopping of fodder trees during winter season (January and February) when other green fodder is scarce and regulates the shade effect on agricultural crops. Among the fodder trees *Ficus* sp., *Artocarpus lakoocha, Litsaea polyantha, Saurauia nepalensis, Vitex heterophylla, Bauhinia purpurea*, etc are the most common agroforestry species (Sharma *et al.*, 1992).

Agri-horti system : There is no clean cultivation of mandarin orange (*Citrus reticulata* Blanco) in Sikkim, it is always intercropped throughout the year. The major intercrops are ginger, ginger + maize, maize-finger millet, maize-urd-mustard, maize, vegetables (especially beans), maize-buckwheat, maize + cassava etc. Among the intercrops, ginger and ginger + maize are the most common every where. The availability of agricultural land is limited is Sikkim due to rugged hilly tarrain, therefore, growers are taking intercrops in orange orchards to meet daily food requirements and earning cash by growing ginger and vegetables. Soil fertility gets improved through recycling of nutrients via animal manures and mulching materials. Farmers

Table 2

Bamboo species available at different elevation in Sikkim

Elevation/Species	Remarks/Use
Upto 900 m	
Dendrocalamus hookeri Munro	Mainly in sal forest
Dendrocalamus hamiltonii	Shoots as vegetable, vessels for water and local wine, baskets, house construction.
Bambusa tulda Roxb.	Best for house building, shoots as vegetable, furniture.
900 to 1800 m	
Arundinaria suberecta Munro	
Bambusa nutans Wall	
Cephalostachyum capitatum var. *decomposita*	Lepchas use for making bow and arrows, house construction, basket.
A. hookeriana Munro	
A. intermedia Munro	Basket making, mats, house tying etc.
A. polystachya Kurz	
D. patellaris Gamble	
D. sikkimensis Gamble	Water and local wine vessels.
Neohouzeaua dullooa	Umbrella handle, house construction, cooking utensils, baskets.
Pseudostachyum polymorphum	Tying houses, baskets, mats.
1800 - 2700 m	
A. maling Gamble	Mats for roofing and floors of the house.
C. fuchsianum Gamble	
C. latifolium Munro	
Teinostachyum falconeri	
Above 2700 m	
A. pantilingii	
Thamnocalamus ariatatus	

All the bamboos are used for fuel (including rhizomes), leaves for fodder, fencing, cremation coffins, small sized bamboos for musical instruments, afforestation of river banks and soil conservation areas, shelter belt, wind breaks, container for cleaning grains, pandals for shade.

also adopt the same practices for taking intercrops with other fruit trees.

Grasses on terrace riser bunds and other lands : Farmers plant the perennial grasses *Thysanolaena agrostis, Setaria palmifolia, Pennisetum purpureum* on the bunds of agricultural land and terrace risers and are entirely local origin. The *Thysanolaena agrostis* also grows well between the trees and wasteland without any input. This grass protects the soil against water erosion even in most vulnerable area. The leaves serve fodder for animals in winter, flowering portion is used for making broom and sticks to make the thatch for animal shed. *Colocacia* sp. are raised in the shady places and field corners and used as pig food.

Homestead gardening : This system consists of house, animal shed, few fruit trees, food crops, vegetables and other trees surrounding the house. The complex mixture of trees and annual crops allows the continuous use of land around the house throughout the year. Recycling of nutrients is very high because for giving the same input to other land farmers have to carry by head load to that distance. This system not only beautify the landscape around the house and improve the environment but directly benefit the crops with which they are associated.

Forest produce for human consumption : Many native tree species are used as edible plants in the habitats of human settlement in Sikkim according to their social customs. Bamboo shoots, wild banana, wild nettle, *Tupistra nutans* and various kind of mushrooms have local demand as delicacies. Fruits of *Podophyllum sikkimensis* and leaves of *Rheum nobile* are much relished at higher altitude where only wild oats grow. Bhutias make the brick tea from the bark of *Betula alnoid*.

Appraisal

An ecosystem is essentially a man-made ecosystem, which provides the human basic needs of food, fodder, fuel, fertilizer, fibre, timber, medicinal and commodity crops, and also giving some economic returns. The traditional concept of agroforestry developed by generations in Sikkim to the agricultural systems so as to reap the maximum benefit from the available resources under a particular set of growing conditions. The three basic elements of agriculture including horticulture, forestry and livestock together meet the demands of the local populations, respectively. Large cardamom plantation is economically viable and ecologically sustainable agroforestry system in Sikkim. This system is a major source of cash to supplement subsistence farming and has considerable unrealized potential. The cultivation of large cordamom with plantation trees on steeply-sloping lands, on which local inhabitants (Lepchas and Bhutias) depend for livelyhood, making the productive use of such lands environmentally acceptable. The other preceding mentioned agroforestry systems offer a practical means of achieving productive output whilst as the sametime maintaining soil fertility.

The productive element arises first, from the capacity to sustain, or even augment, crop or pasture production in the presence of trees, and secondly, through production from the tree themselves as fruit, food, fuel, fodder, timber etc. Practically most of the adopted agroforestry landuse systems require neither most costly external inputs nor complex technology. The multistorey homestead gardening and mandarin based cropping systems posses an inherent capacity to control soil erosion. The planting of bamboos along the drainage channels and on steep slopy lands stabilizes the soil against degradation and gives production from land occupied. Grassed waterways on terraced lands stablize the eroding drainage channel from a field or farm.

Scope of Agroforestry Systems

Hill slope farming, known also as steepland agriculture or mountain agriculture is generally defined as the growing of food and perennial crops on land with a slope exceeding 36 per cent (20 degrees) (Lim *et al.*, 1987). The widespread expansion of steepland agriculture is invariably accompanied by environmental degradation of mountain habitates as well as down stream areas. The population of Sikkim was around 30,000 in 1891 increased to 4 lakhs in a century increased the demand for basic needs such as food, fodder and fuel to a great extent. The increased demands, in turn, lead to reduction in forest density and conversion of forest land to shrubland, overgrazed community pasture or cropland. Therefore, under such situation agri-silviculture, agri-pastoral, agri-silvi-pastural and horti-agriculture are most important in the young frazile mountains of Sikkim. Their successful implementations depends n sustainable agriculture development, proper land use planning and availability of water and all other inputs.

As evident from Table 1, the steeply sloping side slope (>50%) covers an area of 43 per cent. On such type of land horticulture, agri-horticulture and agroforestry have the immense potential for intensification and diversification of biomass production. The farmers of Sikkim

Table 3

Some important local multipurpose trees for agroforestry

Species	Utilization	Altitude (m)
Albizia procera	Lft	< 800
A. marginata	Lft	upto 1500
Arundinaria sp.	LIS	1500-3000
Acer sp.	Lft	1500-3000
Alnus nepalensis	LFts	600-1900
Artocarpus lakoocha	ELIf	upto 1000
Bassia butyracae	EfION	upto 1300
Bauhinia sp.	ElFigs	upto 1300
Brassaiopsis glomerata	Lf	1500-2200
Castanopsis histrix	elFTS	1500-2200
C. indica	ElFTs	600-1200
C. tribuloides	elFTs	upto 2200
Cedrela toona	FT	upto 1000
Cryptomeria Japonica	Flt	1000-1200
Dendrocalamus hamiltonii	EfIMS	< 900
Dalbergia sissoo	fTS	< 600
Elaocarpus sp.	M	800-1500
Erythrina arborescens	LFS	1500-2200
Ficus sp.	LE	upto 1500
Grewia sp.	EFLRIS	upto 1500
Juglans regia	ETFM	900-1800
Juniperus sp.	tfS	2200-3500
Litsaea polyantha	LFt	< 1500
Michelia champaca	LTMO	1500-2000
Michelia daltsopa	LTF	1500-2200
Ostodus paniculatus	Lfe	600-1800
Prunus ceresoides	LFt	1800-3000
Populus sp.	tIFS	upto 2500
Pinus sp.	fTg	1800-3000
Quercus sp.	Ltf	1500-2500
Rhododendron sp.	F	1800-3500
Saurauia nepalensis	L	1500-2000
Schima wallichii	LTtF	upto 1500
Shorea robusta	TlFm	< 600
Tsuga dumosa	Tif	2500-3000

* Glossary of abbreviations on the use of tree species (Burley and Carlowitz, 1983).

Capital and small letters indicate the main and potential use. E,e=edible; F,f=Firewood; G,g=hedges; I,i=small timber/implements; L,l=lopping for animal fodder; M,m=medicinal/religious material; O,o=Oil seed; R,r=fibre/ropes; S,s=soil improvement/ erosion control; T,t=timber.

have the two types of terraces, namely; irrigated flat terraces for rice and rainfed graded to upland crops. Soil erosion occurs on graded terraces more as compared to flat terraces. The conservation of soil includes the erosion and maintenance of soil fertility. Agroforestry practices particularly appropriate on such environments includes barrier hedges, trees on soil conservation works, alley cropping designed to achieve erosion control multistorey tree gardens, plantation crop combinations and multipurpose trees for fuelwood, fodder and soil fertility improvement (Young, 1987). Agroforestry is linked to conditions of the physical environment through plant growth, system management and tree/crop interactions. The indigenous species of some important trees are given in Table 3 for different altitudes of Sikkim to increase the over all productivity on long-term basis. The exotic species of trees can be introduced in agroforestry which can meet the needs of location specific edaphic conditions and the demand of the local population, respectively.

Closely spaced hedges are an alternative to earth bunds as barriers, whilst tree litter from the leaf fall or pruning can provide soil cover. Hedges of *Leucaena leucocephala, Gliricia sepium* and *Sesbania aegyptica* can be used for hedgerow on slopy lands at lower subtropical zone at the specing of 2-4 m intercropped with cereals/pulses in rotation and tree along the drainage ditches can effectively reduce the soil erosion. The nitrogen fixing trees have great potential in developing sustainable and productive agroforestry system and simultaneously protecting the environment also. Thus diversity of soil type, variation of altitude and climatic conditions provide ample scope for growing a variety of agricultural crops, economically important multipurpose tree species and fruits of tropical to temperate climates together to meet the demand of firewood, charcoal, small timber, animal fodder, food, vegetable and fruit to the rural people. Sikkim forest law (1988) have the right of people they can have timber and firewood in addition to free grazing land and collection of fodder from their private lands free of cost which is very much encouraging to farmers to adopt the agroforestry for their own benefit.

The geographical information system and climatic data (rainfall, temperature, humidity etc.) are the basic requirements to determine the areas of validity. The geographical information system includes relief, geology, soil, groundwater, surface water, utilization, biotope and technical infrastructure. These geographical informations can be reproduced in the form of geographical models by means of computer linked methods for the States decision makers for better land utilization. The suitable agroforestry system to suit the local conditions and farmers experiences available has to be taken into consideration for the effective utilization of geographical information as well as environmental and soil factors. It will check the soil degradation and increase the ability of soil plants system to transform efficiently into biomass the energy and the inputs provided.

SUMMARY

The traditional agricultural systems in the different climatic zones of Sikkim have evolved over a long time scale within the historic period. The existing current practices of agroforestry in hill agriculture include large cardamom a plantation crop combination, bamboos all along the stream banks and drainage channel, fodder trees and grasses on terrace risers and wasteland, agri-horti system especially mandarin and intercrops and homestead gardening etc. Practically most of the adopted agroforestry land use systems require neither most costly external inputs nor complex technology. The traditional hill agriculture including horticulture, forestry and livestock together meet the demands of the local people food, fodder, fuel, fertilizer, fibre, timber, medicinal and commodity crops, and also giving some economic return. The indigenous trees are given to increase the over all Productivity on long term basis.

सिक्किम की पहाड़ी कृषि प्रणाली में प्रचलित कृषिवानिकी व्यवहार

पातीराम, एस०बी०एस भदौरिया व आर०सी० उपाध्याय

सारांश

सिक्किम के जलवायु क्षेत्रों की पारम्परिक कृषि प्रणालियों का विकास ऐतिहासिक काल में काफी लम्बे समय तक चलते रहने के फलस्वरूप हुआ है । इस समय चल रही पहाड़ों की कृषि प्रणाली के अन्तर्गत कृषि वानिकी व्यवहारों में संयुक्त फसलों के रूप में इलायची के बड़े-बड़े रोपण क्षेत्र, नदी किनारों और जल निश्चारण नालियों के सभी किनारों पर लगे बांस, जीनेदार खेतों की उठान और बंजरभूमियों पर लगे चारा वृक्ष और घास, कृषि-बागवानी प्रणाली में बीच-बीच में लगाए मुख्यतः मंडारिन, और घरों के आंगन में लगाए बाग आदि सम्मिलित हैं । अपनाई गई कृषिवानिकी भूमि उपयोग प्रणाली में व्यवाहारतः न तो कोई महंगा बाहरी धन निवेश चाहिए और न ही कोई जटिल प्रौद्योगिकी । पारम्परिक पहाड़ी खेती में जिसमें बागवानी, वानिकी और पशुपालन को स्थानीय जनता की भोजन, चारा, ईंधन, उर्वरक, रेशा, प्रकाष्ठ , औषधियां और अन्य वस्तुओं की मांग पूरी करने के लिए साथ मिलाया हुआ है उससे उन्हें कुछ आर्थिक प्रत्याय भी मिल जाती है । उन्हें दीर्घकालिक आधार पर समग्र उत्पादकता बढ़ाने के लिए देशी पेड़ भी दिए जाते हैं ।

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A poetic innovation by a forester

LEHEREIN

A book on ***Shairee*** (poetry) probably one of its own kind ever authored by a forest officer, has been published by Asha Publications. It is written by ***Shri Jarnail Singh***, an IFS officer under penname ***'Sahil'***. The book is a unique collection of 142 rare poems, written between 1990-1995 and portrays the colorful spectrum of life and nature. It is written in ***devnagari*** script. The cover design, sketches and style of presentation qualify it as a ***book with difference***. The book is worth its prices Rs. 150/- only. For further information and order, please contact.

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GROWTH AND BIOMASS PRODUCTION BY *POPULUS DELTOIDES* UNDER AGROFORESTRY IN TARAI OF KUMAUN REGION, U.P.

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Introduction

Cultivation of conventional crops like wheat, maize, lentil, cash crops like potato, sugarcane, mustard, soyabean and fodder crops like sorghum, lucerne and barseem as intercrops with *Populus deltoides* is being practiced and is widely accepted among the farmers of North India. Growing aromatic herbs like Mint and *Cymbopogon* as intercrop with *Populus deltoides* plantation has recently been advocated and is getting impetus because of very high economical return to the farmer due to presence of aromatic oils extracted from these crops. These oils being used in medicine and cosmetic industry have gained very high importance in India as well as abroad.

The study, therefore, was carried out to assess the growth potentials and to quantify the above ground biomass of *Populus deltoides* as sole as well as intercropped stands with Mint and *Cymbopogon* spp.

Materials and Methods

Field experiments were conducted at CIMAP, Regional Centre, Pantnagar, located in Tarai Region of India. Nine treatments namely sole *P. deltoides, P. deltoides + M. arvensis, P. deltoides + M. piperita, P. deltoides + M. citrata, P. deltoides + M. spicata, P. deltoides + M. cardiaca, P. deltoides + flexuouses, P. deltoides + C. winterianus, P. deltoides + C. martinii* at early (2 and 3 yrs) and advance (6 and 7 yrs) age of trees were carried out. Planting of poplar clone G-3 was done at the spacing of 5 m x 4 m, having a density of 500 trees ha^{-1}. The Mint spp. were planted during the month of January while *Cymbopogon* spp. planted during second fortnight of February under the poplar trees at all the age groups.

Diameter at breast height (dbh) i.e. 1.37 m were measured by vernier calipers and height of the trees were measured by Abney's level. In order to assess the tree biomass selective Harvest Technique (Ovington, 1962; Newbould, 1967), commonly known as stratified tree technique (Art and Marks, 1971) was followed for determining the biomass of poplar trees at their young and old age groups both in sole and intercropped stands. The above ground biomass was assessed by separating parts into bole, bark, branches and foliage. The fresh weights of these components were recorded immediately after felling and logging of the trees.

Results and Discussions

Due to easier agricultural operations

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in the present agroforestry system where in the stands were intercropped with Mint and *Cymbopogon* spp. to obtain maximum production of tree biomass without any detrimental effect on the growth and production of intercrops, the tree spacing at 5 m x 4 m used, was the best suitable spacing. Diameter and height at different ages of poplar tree in sole as well as in intercropped with various Mint and *Cymbopogon* spp. are given in Table 1.

The growth of poplar is a reflection of many factors, viz. genotypes, climate and soil conditions, care of trees, use of fertilizers, frequent cultural operations and irrigation schedules. Therefore it has been observed that trees grown under agroforestry attained higher growth as compared to those grown in forest conditions (Singh *et al.*, 1988).

The study also revealed from the Table 1 that the trees grown in stands treated with Mint and *Cymbopogon* spp. attained better height and dbh in comparison to sole stands at all the ages.

While observing the per cent values of various components of the above ground biomass with that of total biomass in Figure 1 (a, b, c) it is revealed that in all the age groups of poplar the contribution of the bole wood remained highest which was followed by branches, foliage and bark both in the sole and treated stands. The contribution of bolewood biomass was highest (60.39-67.83%) in the sole stand whereas it remained lowest in the stands treated with *M. arvensis* (53.97-64.86%). The remaining treated stands with *Mentha* and *Cymbopogon* spp. showed values in between at all the ages. The contribution by the branches varied from 17.73 to 13.71% from 2 to 7 years in a decreasing order in the sole stand which showed lowest values in comparison to various intercropped stands. The values remained maximum in *M. arvensis* (20.28 - 14.24%) followed by stands treated with other *Mentha* and *Cymbopogon* spp. The contribution of biomass by branches was lowering the *Cymbopogon* than the *Mentha* treated stands at all the ages.

The contribution of foliage to the above ground biomass varied from 15.56 to 9.19% in the sole stand and from 16-97 to 10.37%

Table 1

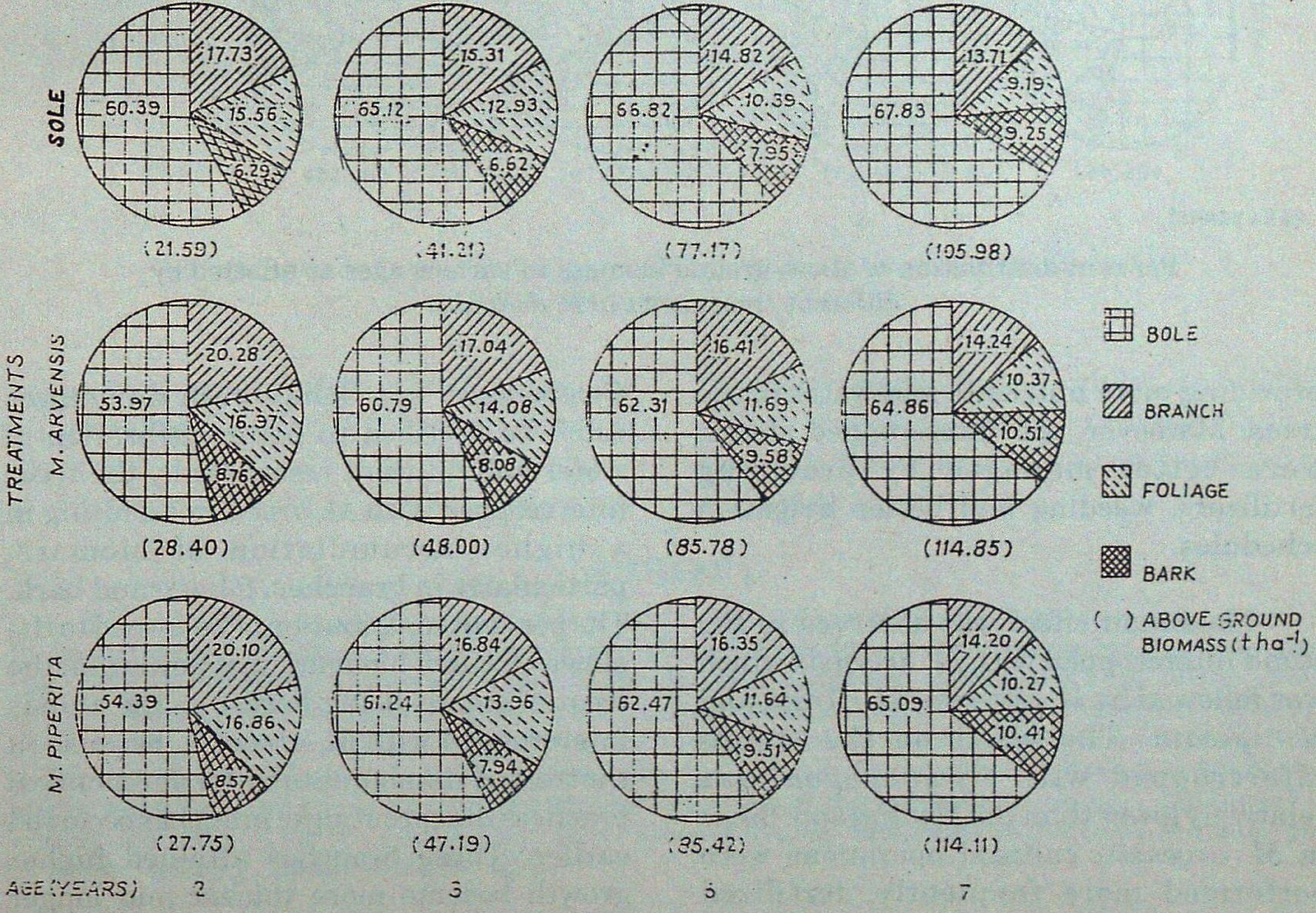
Diameter and height of Populus deltoides at different ages as affected by various treatments

Age (years)	Diameter (cm)				Height (m)			
Treatments	2	3	6	7	2	3	6	7
Poplar (Sole)	6.5	11.4	21.2	22.3	9.8	11.1	19.7	20.4
Poplar + *M. arvensis*	8.6	13.9	23.5	24.7	11.2	12.5	21.1	21.8
Poplar + *M. peprita*	8.4	13.6	23.4	24.5	10.9	12.2	20.8	21.5
Poplar + *M. citrata*	8.3	13.4	23.2	24.3	10.7	12.0	20.6	21.3
Poplar + *M. spicata*	7.9	13.2	23.0	24.0	10.4	11.7	20.3	21.0
Poplar + *M. cardiaca*	8.0	13.4	23.1	24.1	10.6	11.9	20.5	20.2
Poplar + *C. flexuouses*	7.2	12.3	22.7	23.8	10.1	11.4	20.0	20.7
Poplar + *C. winterianus*	7.9	12.2	22.6	23.5	10.0	11.3	19.9	20.6
Poplar + *C. martinii*	7.6	12.8	22.8	23.9	10.2	11.5	20.1	20.8

in the stands treated with *M. arvensis.* Corresponding values for other stands treated with *Mentha* and *Cymbopogon* was in between the sole and *M. arvensis* treated stands at all the ages. The contribution by the bark to the total above ground biomass was found highest in the stands treated with *M. arvensis* (10.51-8.76%) and lowest (9.25-6.25%) in the sole stands at all the ages. The values in other treated stands at all ages remained in between the sole and *M. arvensis* treated stands. *Cymbopogon* treated stands showed lower values in comparison to Mint treated stands at all ages.

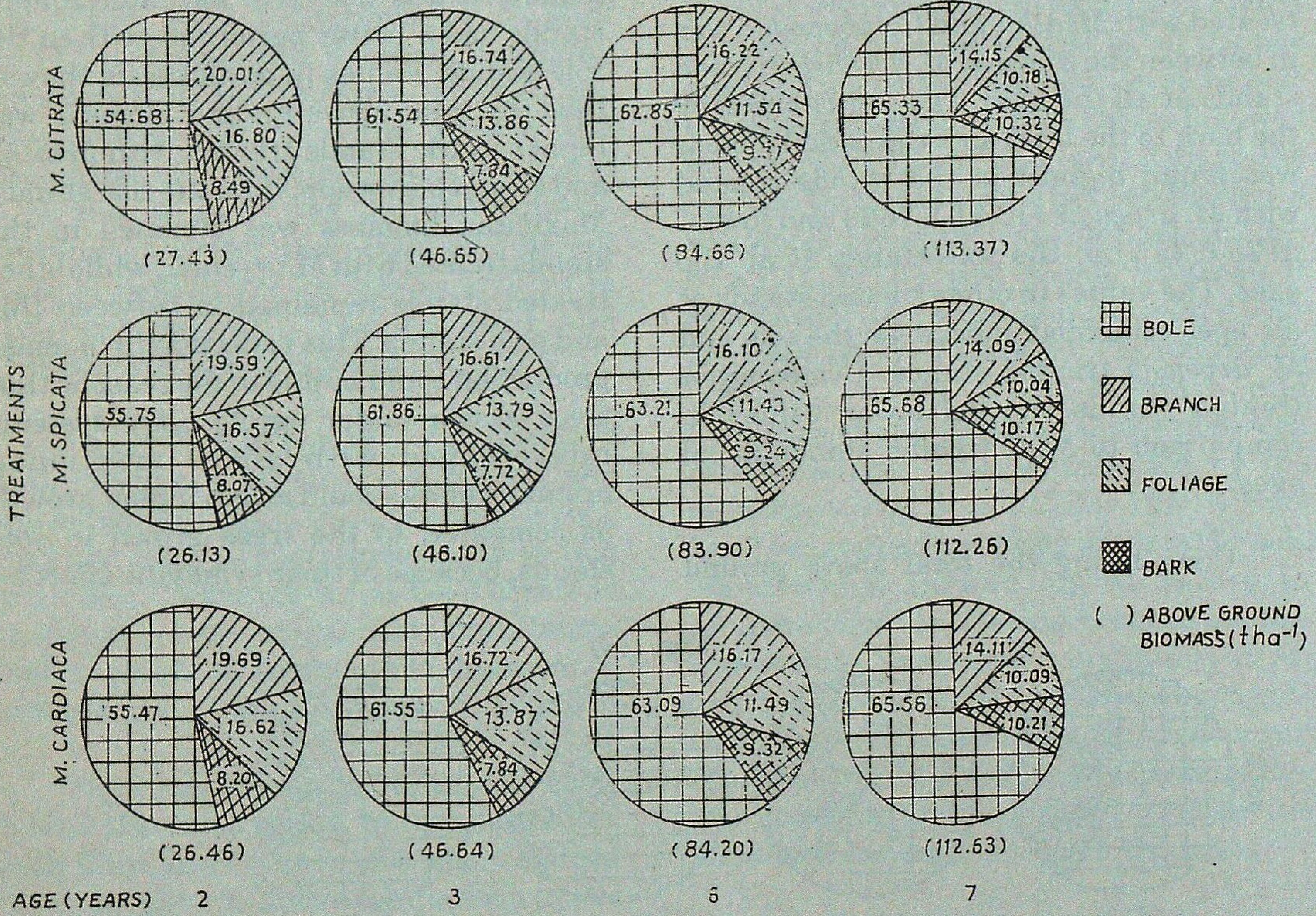
Considering the total above ground biomass (values in parenthesis in Fig. 1 a, b and c) it was observed that intercropped stands had a better performance than the sole stands. Values in parenthesis showed that the total above ground biomass was higher in the stands treated with *Mentha* and *Cymbopogon* spp. than the sole stands. Maximum biomass was attained in the stands treated with *M. arvensis,* while other treated stands remained in between this and sole stands. This reflection in biomass production could be due to the reasons that trees grown under agroforestry systems intercropped with above mentioned aromatic plants could attain higher growth as compared to the trees grown in sole stands, because of their symbiotic effect by

Fig. 1(a)



Per cent distribution of above ground biomass in various ages as affected by different treatments in *P. deltoides*

Fig. 1(b)

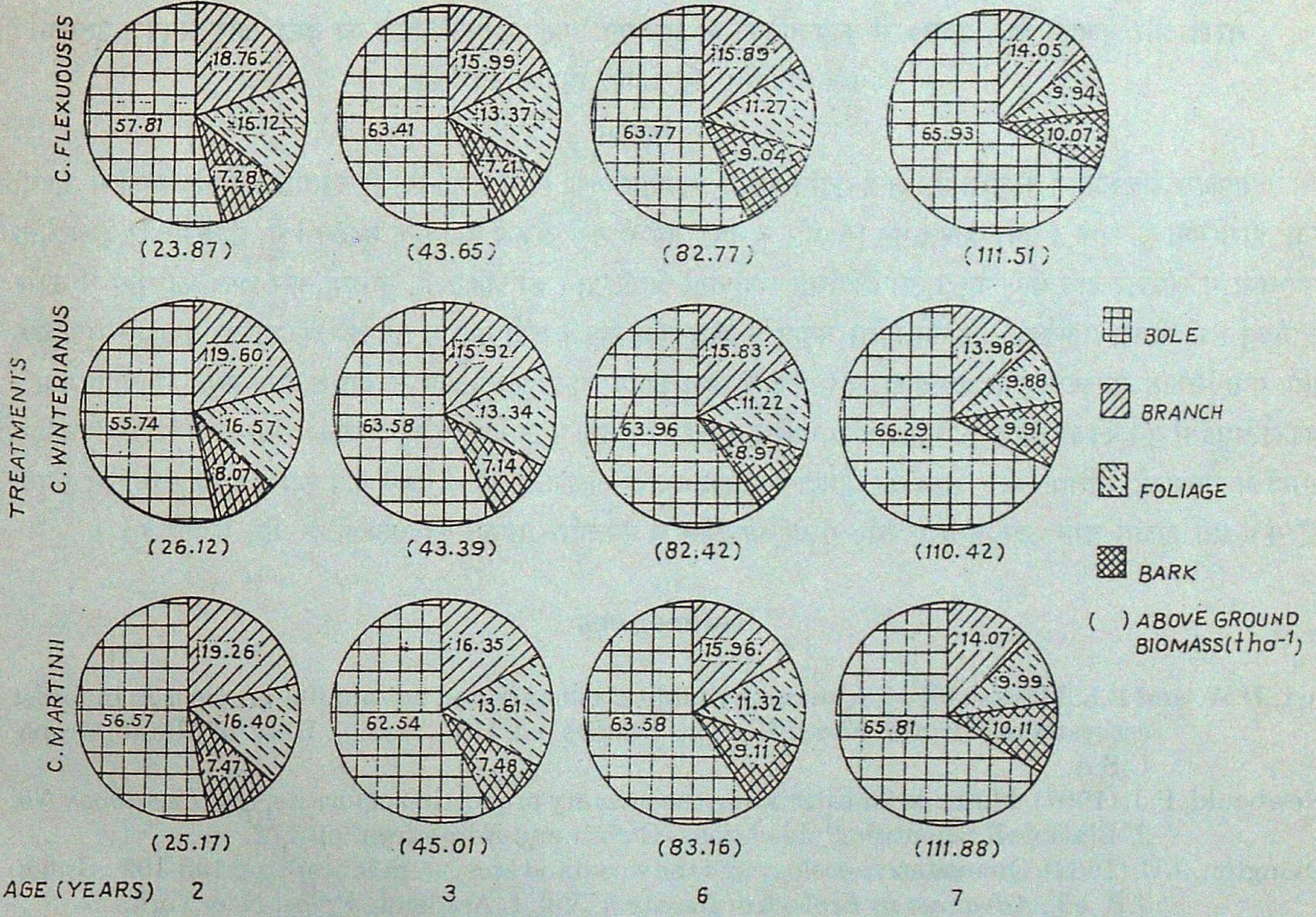


Per cent distribution of above ground biomass in various ages as affected by different treatments in *P. deltoides*

providing more nutrients and water to the trees. Moreover, the intercropped stands were better managed by providing fertilizers, weeding and better irrigation schedules.

Maximum effect was observed in the stand intercropped with *M. arvensis* which was followed by *M. piperita, M. citrata* and *M. spicata*. The effect on the stands intercropped with *Cymbopogon* was relatively lower than the *Mentha* spp. Since in *M. arvensis,* cultural operations were performed more frequently, fertilized heavily, and irrigated frequently in comparison to other *Mentha* and *Cymbopogon* spp. hence such differences could be ascribed to better utilization of water and nutrient resources by the trees intercropped with *M. arvensis* resulting in a higher accumulation of biomass, particularly in branches, foliage and bark. The per cent contribution of bolewood to the above ground biomass was lower in the treated stands being lowest in the stands intercropped with *M. arvensis,* because in the treated stands due to better agronomical practices the sprouting of branches occurred earlier. These branches attained higher growth became more thicker and longer having more twigs and foliage thus provided higher proportion to the above ground

Fig. 1(c)



Per cent distribution of above ground biomass in various ages as affected by different treatments in *P. deltoides*

biomass in comparison to bole which though attained higher dbh but remained lower in its crown depth and provided lower proportion to the above ground biomass in the intercropped stands. Pandey *et al.* (1989) observed that the tree biomass was found to be much higher in irrigated as compared to the unirrigated areas.

SUMMARY

Populus deltoides **trees grown in stands treated with various Mint and** ***Cymbopogon*** **spp. attained better height and dbh than their sole stands at their early (2 and 3 years) and advanced (6 and 7 years) ages. The contribution of various components viz., bole branches, foliage and bark to the above ground biomass varied in the sole and treated stands. At all the ages the contribution of bolewood remained highest followed by branches, foliage and bark both in the sole and treated stands. Bolewood contribution was maximum in the sole in comparison to treated stands, whereas contribution of branches, foliage and bark remained highest in the stands treated with** ***M. arvensis*** **and lowest in sole stands. The respective values for other treated stands remained in between the sole and** ***M. arvensis*** **treated stands at all the ages.**

तराई और कुमाऊँ क्षेत्र, उ०प्र० में कृषिवानिकी के अर्न्तगत *पापुलस डेल्टायडिस* की वृद्धि और जैवपुंज उत्पादन

फैज़ मोहसिन, आर०पी० सिंह व के० सिंह

सारांश

पापुलस डेल्टायडिस के वृक्षों में, जिन्हें पुदीने और *सिम्बोपोगोन* की विभिन्न जातियों से उपचारित करके समूहों में उगाया गया, प्रारम्भिक (2 और 3 वर्ष) और प्रगत (6 और 7 वर्ष) उम्रों में उन्हें अकेले उगाने के मुकाबले में, ऊँचाई और वृक्षोच्चता पर व्यास में श्रेष्ठतर होते पाए गए । उसमें विभिन्न संयोगांगों अर्थात् तने की शाखाओं, पत्तियों और छाल का भूमि से ऊपर के जैवपुंज में योगदान अकेले और उपचारित समूहों में भिन्न-भिन्न रहा । सभी उम्रों में तने की लकड़ी का योगदान सर्वाधिक पाया गया जिसके बाद क्रमानुसार शाखाओं, पत्तियों और छाल का योगदान, अकेले और उपचारित दोनों समूहों में, पाया गया । अकेले समूह में तने की शाखाओं का योगदान उपचारित समूहों की तुलना में अधिकतम रहा जबकि *मेन्था आर्वेंसिंस* से उपचारित समूहों में शाखाओं, पत्तियों और छाल का योगदान सर्वाधिक तथा अकेले समूहों में सबसे कम. रहा । अन्य उपचारित समूहों की संबन्धित अर्हाएं सभी उम्रों के लिए और *मेन्था आर्वेंसिंस* से उपचारित समूहों की अर्हाओं के बीच में पाई गई ।

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MARKETING OF FARM FORESTRY PRODUCE : A NEW CHALLENGE FOR FARMERS

A. K. PATNAIK*

Introduction

The present wide gap between the demand and supply of wood can be bridged to a considerable extent, if Farm Forestry and Agroforestry can be popularised by making it a people's movement. The products from such farming have got good potentialities as raw material for wood based as well as other Industries. Most of the farmers adopted Farm Forestry with their experience of disposal of Agricultural produce, which has got an established marketing infrastructure and market information system, On the contrary marketing of forest produce, which happened to be a State monopoly, little information about it's marketing is actually available to the farmers. Unlike the seasonal agricultural crop the forest crop being a long rotation crop, it involves a greater risk and more resources. The vital components of marketing like market potentiality, market environment, market out-let of the locality, proper marketing strategy along with the other inherent bottlenecks like the stringent Acts and rules applicable for removal and transportation of wood need careful examination to popularise the farm-forestry movement. From the analysis of past experience of the farmers of some of the States like Haryana, Gujarat, Maharashtra, Andhra Pradesh, Orissa, it can be concluded that unless due weightage is being given to the marketing aspect, it will have a disastrous effect on this popular movement.

Present Scenario in few States

In Haryana, large number of farmers adopted *Eucalyptus* as a species for tree farming in a mass scale being attracted by the lucrative price offered by the Paper Industry. Unfortunately it led to a glut situation and objective with which the farmers went for massive Farm Forestry were frustrated. It all happened due to the lack of information about the market i.e. the market environment. Only one paper mill happened to be the major buyer and the farmers also adopted a closer spacing to meet the demand of the paper mill.

In Maharashtra the farmers went for massive plantation of *Leucaena* (Subabul) during early 80s without giving any thought about its market prospects. They were carried away by an impression that it has got great demand as pulp wood. The farmers accordingly adopted density plantations i.e. plantation at a closer spacing of 1 m x 1 m, suitable for pulp industry. When the crop become ready for harvest, the farmers to their dismay found that there is no promising market for *Leucaena* crop particularly in Maharashtra. Some of the farmers are so much perturbed that during field visits in the State of Maharashtra, the author came across certain progressive

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farmers of Nagpur and Wardha District, who expressed their anguish for taking the wrong decision. Some of them even expressed that, they would uproot and burn it as slash if they do not get any market outlet within a short span, so that they can put the land into some alternate use. Now the progressive farmers of Maharashtra are switching over to Teak and Bamboo plantation in a massive way and from their past experience now they have learnt a lesson and are going for species which has got very good future market.

In case of Andhra Pradesh, the farmers have adopted *Casuarina* as the principal Farm Forestry species. *Casuarina* is exempted from the purview of transit permit by the Forest Department, Andhra Pradesh, and no transit permit is required for its movement inside the State. The result is that the farmers are greatly encouraged to plant *Casuarina* in a massive way due to elimination of its restriction on the movement. The *Casuarina* poles from Andhra Pradesh are now found to be sold in a much competitive price at various cities of Orissa, Maharashtra and adjoining States. The selling price even after addition of the transportation cost seems to be much competitive in the market of Orissa, West Bengal and Maharashtra and the price is so competitive that the local producers fail to compete with the *Casuarina* poles of Andhra Pradesh. The reasons being :

(i) Liberalisation of the Transit Rule,
(ii) Proper market information system with other sound features like competitiveness, price control, demand supply balance by exploiting the market avenues of other States.
(iii) Proper technical planning i.e. versatile use of the *Casuarina* as pole for constructions purpose, as excellent firewood and as raw materials for pulp industry.

Analysis

The major bottlenecks in the marketing of Farm Forestry produce are the lack of market infrastructure, marketing plan, lack of proper planning of produce manufacturing system and produce disposal system. In addition to this the stringent act and rules for removal of forest produce even from the private holdings and lack of agencies to facilitate the marketing are perhaps the major stumbling blocks.

(a) In case of Haryana the farmers adopted wide scale plantation of *Eucalyptus* at a closer spacing keeping in view the market prospects of local Paper Mill. This was again without any commitment from the Paper Mill. So the final produce was only fit as raw-material for pulp wood industry. The mass production without assessing the market potentiality led to a glut situation, to the advantage of the pulp industry of the State which created a state of Buyer's market. The final produce was also not fit for any viable alternate use. The farmers become production oriented and the sound marketing planning was never given any thought, this resulted into a glut situation of end product to the advantage of pulp industry. So this typical situation arised due to lack of :

(i) Marketing infrastructure,
(ii) Marketing planning,
(iii) Demand-Supply balance by exploiting other market avenue,
(iv) Proper planning of produce manufacturing system and produce disposal system.

The constraints can be overcome by

development of proper market information system. By proper planning and appropriate technology, the produce can be changed to a flexible one in its use by adoption of appropriate spacing etc. Similarly the marketing by Co-operative can be effective.

(b) In case of Maharashtra the major constraints in marketing of *Leucaena* crop was due to improper planning. During adoption of spacing the farmers did not take marketing in proper perspective, as a result of which an elusive scenario emerged i.e. they again adopted close spacing as per the requirement of the pulp industry, but when the crop became ready for harvest, they found no proper buyer. Thus technically the produce manufacturing system was not taken care of properly at the right stage.

(c) In the light of the above analysis, the situation in Andhra Pradesh seems to be better in the sense that proper selection of species with multiple use i.e. *Casuarina*, suitable for pole, firewood, pulpwood. Proper care was also taken for analysing the demand supply balance by exploring market avenue even in the neighbouring States. Right weightage on produce manufacturing systems i.e. by adopting suitable technical procedure, that is proper spacing and post-planting care which resulted in versatile end product. Thus there is proper planning both at manufacturing stage and disposal stage. In addition to this the liberalisation of the transit rules is another positive factor for the successful farm-forestry movement in Andhra Pradesh.

Conclusion

Taking into consideration the grim scenario of the demand and supply balance of basic forest produce in India, the farm forestry needs to be popularised, so that it can become a people's movement. The major bottlenecks which needs to be eliminated are :

(i) Basic market information like the price control, Demand and Supply balance etc. which are not clear to the growers, most of the times.

(ii) The proper thought and planning for the produce or product manufacturing system is not yet given proper weightage by the farmers, as seen from the present scenario of the various stages, as for example the wrong selection of spacing and wrong choice of species created a havoc during disposal of the final produce, in Haryana and Maharashtra State during the initial stage. So proper planning of the forest produce manufacturing system keeping in view the produce disposal system is essential.

(iii) The existing laws and rule for transportation of forest produce needs careful examination. The rule should be liberalised so that the farmers are encouraged to adopt more of farm forestry.

(iv) Further the present trend of dependence of the forest based industries completely on the forest, needs reorientation and certain change at policy level is required so that the industries in turn will encourage farm forestry, so that steady and sustainable supply of raw-materials can be ensured.

(v) In addition to this, since many small and marginal farmers are seen to be adopting farm forestry the produce will be a new item for them as regards disposal, contrary to the agricultural produce which has got well established market infrastructure and information system, the marketing of farm forestry produce will be a new challenge for them. Formation of Co-operatives will go a long way in making this movement a grand success.

SUMMARY

Marketing seems to be the greatest challenge for the farmers who have adopted Farm Forestry in a big way. The lack of basic knowledge about the marketing, particularly the marketing mechanism like demand supply balance, effective marketing plan, market environment, seems to pose major threat to this great popular movement. In this paper the present scenario of some of the States is analysed and the major constraints in marketing of farm forestry produce are identified and few suggestions to avert these constraints are listed.

क्षेत्र वानिकी उपज का विपणन - किसानों के लिए नई चुनौती

ए०के० पटनायक

सारांश

विपणन करना उन किसानों के लिए, जिन्होंने क्षेत्र वानिकी को ज्यादा विस्तार से अपनाया है, सबसे बड़ी चुनौती प्रतीत होता है । विपणन के बारे में आधारभूत जानकारी विशेषकर के मांग और प्रदाय के संतुलन जैसी विपणन की यन्त्र शैली का ज्ञान न होना, इस लोकप्रिय आन्दोलन के लिए एक बड़ा खतरा खड़ा करता लगता है । प्रस्तुत अभिपत्र में कुछ राज्यों में इसकी वर्तमान स्थिति का विश्लेषण किया गया है तथा क्षेत्र वानिकी की उपज को बाजार में बेचने की प्रधान बाधाओं को पहचाना गया है एवं सूची बृद्ध की गई इन बाधाओं को दूर करने के लिए कुछ सुझाव भी दिए गए हैं ।

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INTENSIVE MANAGEMENT OF TEAK (*TECTONA GRANDIS*) PLANTATIONS UNDER IRRIGATION ON FARM LANDS - SOME OBSERVATIONS

M.S. HAQUE*

Introduction

Teak (*Tectona grandis*) is invariably raised under rainfed conditions, but of late many farmers have started raising the tree under irrigation. Although it is certain that Teak raised under irrigation will lose timber quality, especially in strength and grains, for which the tree is famous, but because of its high value and ready market, farmers have chosen it for getting quick returns under Farm forestry. Forest Development Corporations (FDCs) of many States have been raising teak under rainfed conditions since long and many with institutional finance, but in no case intensive irrigated Teak plantations have been approved by the banking institutions. The closest espacement approved is 2 m x 2 m accommodating 2500 trees per hectare.

However, recently a number of teak proposals with plant population as high as 10,000 per ha were submitted by several financial institutions and all were rejected, although banks had opined that farmers had already successfully raised intensive teak plantations under irrigation and hence insisted for an on the spot study of such plantations. Since we were also not sure about the technical and financial viability of such intensively managed irrigated Teak plantations, it was thought essential to undertake an indepth techno-economic feasibility study for proper evaluation that could be the basis for financing of such schemes. The present paper reports some of the most interesting observations recorded during the field visit undertaken in Periyar District of Tamil Nadu.

Study Area

The Periyar District has a geographical area of 8,23,299 hectares accounting for about 6.3 per cent of the total area of the State. The soils are mostly red, sandy and red gravel with moderate amounts of red loam and occasional black loam. Vast stretches of the upland regions are mostly stony and gravelly. Forest area is 2,32,920 hectares, which works out to 28.3%. Around 10% of the land is considered as wastelands. The major crops are paddy, Groundnut and Sugarcane. Crops are mostly raised under irrigation, since the climate remains hot and dry throughout the year. The normal average annual rainfall is 717 mm but in some of the years it is less than even 500 mm i.e. the behaviour of rainfall is erratic.

Study team and plantations visited : A team of officers led by the author from financing banks visited 2 Teak plantations in Anthiyur block, aged 1 year 6 months (6 acres) financed by Canara Bank and 3 years 6 months

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(3 acres) raised through own resources; and 4 plantations in Arachalu block all raised through own resources aged 5 years (1 ½ acres), 6 years (2 ½ acres), 7 years (2 ½ acres) and 11 years (1 acre).

Observations

Land characteristics : The lands where intensive irrigated teak plantations were raised were agricultural lands but of very poor quality with low fertility, soils were red, sandy, mixed with pebbles and stones. In some cases lands were uplands too. The team was of the opinion that for all practical purposes, such lands may be considered as wastelands.

(a) *Teak stumps* : Stumps were procured from Social Forestry unit of Forest Department and initially cost was only 25 paise per stump. At present the demand is so high that Forest Department is unable to meet it, hence interested farmers are purchasing the stumps from private nurseries even at a cost of Rs. 2 per stump.

(b) *Espacement* : In all the plantations visited by the team roughly an espacement of 1m x 1m was followed accommodating 4000 trees per acre. It was also observed that few farmers used spacing of 120 x 120 cm and even 90 x 90 cm. Some had intermixed coconut trees with teak too.

(c) *Thinning* : No farmer had practiced thinning and was even reluctant to do this, since they thought that weak trees would die naturally in due course of time and were happy in the sense that the surviving trees would give them high returns during final harvesting, hence were not interested to incur any further cost in thinning operations. This was the case in the plantations raised by the farmers with own resources. The farmer who had raised teak plantation with financial assistance from Canara Bank had a plan to remove 50% trees in 5th year for pole production.

(d) *Irrigation and fertilization* : The farmers who raised intensive teak plantations were all big and progressive and took extra care for the trees especially by providing regular fortnightingly flood irrigations upto 5 years and also added nitrogenous fertiliser. Some of the farmers however provided irrigation only when excess water was available and after meeting the requirements of their agricultural crops. Hence in many cases irrigation schedule was not followed although the farmers were convinced that without irrigation, teak plantation would not succeed in the district and cited an example of a teak plantation financed by Indian Overseas Bank in the same area, which failed due to lack of irrigation facilities. An interesting observation noted by a farmer was that he thought it was not necessary to irrigate teak beyond 10 years.

(e) *Intercropping* : Although few farmers tried to cultivate soybean, groundnut and cotton in first year, it did not succeed because of very close planting of teak trees. Farmers also felt that cotton affected the growth of teak but not soybean.

(f) *Cultural operations* : Weeding, soil working and application of pesticides were done by the farmers but not on a very strict schedule.

(g) *Cost / expenditure* : No systematic unit cost was followed by the farmers and only need based expenditure was incurred by them, since the plantations were self-financing. However, on enquiry from the farmers it was revealed that the expenditure incurred upto 5th year for 1 acre intensive, irrigated Teak plantation varied between Rs. 25-30,000.

(h) *Growth, yield and returns* : It was observed that teak grew well under irrigated conditions in the district. In a 1 year 6 month old plantation raised in Nakalur village with 1 m x 1 m espacement trees attained average height of 5 m with 15 cm girth. Trees were straight with hardly any branches. The farmer was confident that he would get Rs. 150 per pole in 5th year and he expected a girth of 50 cm by that time. Survival was more than 80%.

In another three and a half year old plantation raised in village Settukkttupudur with 120 x 120 cm espacement, it was observed that out of 6000 trees planted in 3 acres, 4500 survived and attained an average girth of 20 cm. He also planted coconut trees in between and wanted to remove all teak tress by 5th year and retaining the coconut trees. He hoped that he would get at least Rs. 100 per Teak pole during harvesting.

In a 7 year old plantation with 1m x 1m espacement, survival was only 60%. Some of the trees attained a girth of 48 cm averaging 25 cm. The farmer hoped that by 10th year he would get a minimum price of Rs. 250 per pole.

In an 11 year old plantation raised by a lawyer, the trees attained a maximum girth of 56 cm averaging 30 cm, but the survival was less than 50%. He expected that his good trees would give him a return of Rs. 500 per tree. Most interesting observation of this farmer was that he favoured a 2 m x 2 m espacement than the earlier 1 m x 1 m practiced by him.

Canara Bank Scheme : It proposed to raise teakwood plantations in 20 hectares of wastelands in Anthiyur block with a plant population of 10,000 trees per ha by using 1 m x 1 m espacement. The per hectare unit cost upto 5 years was estimated at Rs. 60,000. Taking into the survival rate at 80%, about 8000 trees were to be available for harvesting. About 50% of the standing trees were to be cut in 5th year and the remaining trees were to be cut in 9th and 14th years. The details including the sale price and income was estimated as provided in Table 1. The scheme had an IRR of 38.20% indicating its technical and financial viability.

Marketing : A highly demanding market for teak poles and timber was found to be available in the district. The traders were ready to purchase the trees on the farm itself and making arrangements by themselves for cutting and transporting. Such traders were coming from Erode, Bhavani, Sathiyamangalam and other nearby places of the State. Besides, there was a good market for teak poles locally for

Table 1

Canara Bank Scheme for Teak Plantation

1 hectare model farm. Plant population = 10,000
Cost per ha = Rs. 60,000 upto 5 years. Survival = 80%

Year of harvest	No of poles harvested	Price per pole	Total income (Rs.)
5	4000	25.00	1,00,000.00
9	2000	80.00	1,60,000.00
14	2000	250.00	5,00,000.00

drying of cotton yarns which is a household activity in the area. A visit to a timber depot revealed that teak poles of 6-7 length and 30 cm girth were sold at Rs. 120. These were brought from Kerala.

Conclusion

Teak is one of the best timber trees of our country. Although generally teak was believed to be slow growing but now-a-days with improved techniques and sound management it has been found to be suitable as a short rotation crop under Farm Forestry. Many private people have already floated companies asking investment in teak equity. Although their sole objective is to lure the public for getting easy and quick money, it is felt that teak is really a good tree for investment and is going to be a favourable species to the farmers for a long time. Of course the cost and returns proposed by the companies are not only unjustified, but also not supported by any scientific data. Their promised returns of more than Rs. 50,000 per tree in 20 years and also investment of Rs. 1,000 per tree is not only unrealistic but also disproportionate to the actual planting cost (Chaturvedi, 1995). It is believed that an investment of Rs. 6-7 per tree upto 5th year is sufficient for raising an intensive, irrigated teak plantation. However, progressive thinning in 5 and 10 years is recommended with a final harvest of 2000 trees per hectare in 15th year (Table 2). So long specific projects with clearcut objectives are formulated, intensive, irrigated teak plantations are considered both technically feasible and financially viable. In fact in Mizoram State alone few million teak trees have been raised on jhumlands under Farm Forestry (Haque, 1994).

Eyebrows may be raised by the Forester's community on the close plantings of Teak, but is must be kept in mind that there have been sea-changes in Forest Management techniques and the farmers have already adopted these for producing more on their farm lands, within the shortest possible time. We may not encourage these schemes in a big way, but may recommend those where the farmers are progressive and with big land holdings. We may even approve these schemes for availing of institutional finance, if wastelands are to be developed. The observations suggest that a change in the attitude and policy towards intensive teak plantations might be necessary.

We may not stick to the idea of quality wood with strength and grains for which teak is famous, since there is an existing market for any teakwood - sap or heartwood, even adulterated timbers are sold in the market in the name of teak. Nobody approved the way Kalidasbhai Patel raised intensive *Eucalyptus* plantations on his farm lands with his own resources and earned

Table 2

Recommended Scheme for Teak Plantation

1 hectare model farm. Plant population = 10,000
Cost per ha = Rs. 56,705.00 upto 5 years. Survival = 80%

Year of harvest	No of poles harvested	Price per pole	Total Income (Rs.)
5	4000	25.00	1,00,000.00
10	2000	100.00	2,00,000.00
15	2000	200.00	4,00,000.00

high returns, much more than he could get from wheat or cotton cultivation. He had shown what could be achieved in a short time with tree farming. What is now necessary is to repeat such work with teak by combining available technology and management (Reddy, 1995). A recent observation by an author (Ghosh, 1995) from his wide experiences mentioned that teak trees raised from selected clones, adequately and scientifically managed can attain significant height and diameter growth at 20 years, although may not have the same quality, volume and market value like 60 year old trees. But then intensive teak plantation on farm lands is not for quality, rather it is for quantity which is a necessity in a wood starved market. However, judicious irrigation will work out to be more attractive financial proposition than flood irrigation (Gogate *et al.*, 1995). The responsibility of preserving the quality of teak must rests with the Forest Departments which raise it on forest lands.

SUMMARY

The paper deals with the technical feasibility and financial viability of intensive, irrigated Teak plantations. The author has based his observations after visiting such plantations in Periyar District of Tamil Nadu. He suggests that intensive, irrigated Teak plantations may not have the qualities for which teak is famous, but definitely such wood has a ready use in an otherwise wood starved market. He further recommends that such schemes are not only technically feasible but also financially viable and are eligible for availing of institutional finance, if raised for development of wastelands. IRR of such schemes exceed 30%.

खेतों पर सिंचाई करके लगाए सागौन (*टैक्टोना ग्रांडिस*) रोपवनों का सघन प्रबन्ध करना - कुछ विचार

एम०एस० हक

सारांश

प्रस्तुत अभिपत्र में सघन लगाए, सिंचित सागौनं रोपवनों की प्राविधिक सुशक्यता और वित्तीय समर्थता पर विचार किया गया है । लेखक ने अपने विचार तमिलनाडु के पेरियार जिले में लगे ऐसे लगे रोपवनों का निरीक्षण करने पर आधारित किए हैं । उन्होंने सुझाया है, हो सकता है कि सघन लगे सिंचित सागौन रोपवनों में वे सब गुण न मिलें जिनके लिए सागौन विख्यात है परन्तु निश्चयपूर्वक तत्काल उपयोग के लिए बाजार को ऐसा काष्ठ मिलेगा जो अन्यथा लकड़ी की कमी से भूखा मर रहा है । आगे वे यह भी अभिस्तावित करते हैं कि ऐसी योजनाएँ प्राविधिक दृष्टि से सुशक्य तो है ही वे वित्तीय दृष्टि से समर्थ है और संस्थागत वित्त पाने के लिए सुपात्र हैं यदि उन्हें बंजर भूमियों का विकास करने के लिए लगाया जा रहा है । ऐसी योजनाओं से प्रत्याय की आन्तरिक दर 30% से अधिक रहती है ।

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COMPATIBILITY OF ARABLE CROPS INTERCROPPED WITH *DALBERGIA SISSOO* FOR SUSTAINABLE RAINFED AGRICULTURE

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Introduction

Arable farming since last several years, specially in dry lands, has not proved profitable on account of aberrations of monsoon. It is only during the recent years, that agroforestry, a system of integration of trees with arable crops, proved successful in arid regions as a perennial practice to replace traditional arable farming. Inclusion of certain Nitrogen Fixing Trees (NFT) like sissoo (*Dalbergia sissoo*) in the system offers immense possibility of supplementing a part of nitrogen requirement of the associated crops besides enriching the site through addition of organic matter. It plays a vital role, being leguminous, deep rooted and deciduous in nature. In addition, Sissoo trees also provide fuelwood, off season fodder and small timber to cater to the basic needs of poor farmer in dry lands which are very much in short supply.

Keeping in view the importance of agroforestry system as a sustainable cropping system, the present investigation is initiated to study the compatibility of arable crops in association with *Dalbergia sissoo* in dry lands on red sandy loam soils at Students' Farm, College of Agriculture, Rajendranagar, Hyderabad.

Materials and Methods

A field experiment was initiated during 1991 in randomised block design with two replications. The treatments consisted of combinations of three arable crops with sissoo (sissoo + sunflower and sissoo + redgram) and respective sole crops and sole sissoo.

About 3-4 months old seedlings of *D. sissoo* were planted in pits of 30 cm^3 during post monsoon period of 1990 at a spacing of 4 x 3 m. The gross plot size was 14 x 9 m. Pot watering was done whenever required till the rainy season for better establishment during the first year of plantation. The three arable crops viz., sunflower, castor and redgram were sown as intercrops during Kharif seasons of 1991 and 1992 with a spacing of 60 x 20 cm, 60 x 30 cm and 60 x 30 cm respectively. The crops were fertilized with a common dose of 60 kg P_2O_5 + 60 kg K_2O /ha at the time of planting, whereas nitrogen was applied at the rate of 120 kg, 100 kg and 40 kg/ha to sunflower, castor and redgram respectively in two splits i.e. at the time of sowing and flowering. The trees were fertilized with 50 g of DAP at the time of planting and 100 g of DAP in two doses during monsoon season only in first year of plantation.

The increment in tree growth represents the actual tree growth with respect to height and girth during the period from sowing to harvesting of arable crops.

Results and Discussions

(a) *Performance of arable crops in association with D. sissoo* : The perusal of data in Table 1 reveals that the mean seed yields of sunflower and castor crops (4.38 and 4.86 q/ha) were not influenced due to growth of sissoo when grown as intercrops in comparison with the seed yields of respective sole crops (4.48 and 4.77 q/ha) respectively. This shows the beneficial effect of sissoo which did not compete with the associated arable crops like sunflower and castor during the initial two years of plantation indicating the compatibility of tree crop association. The study conducted on compatibility of crop and tree association. The study conducted on compatibility of crop and tree association by Khattak *et al.* (1980) revealed that the yield of wheat in association with *Dalbergia sissoo* was significantly higher than that with *Eucalyptus camaldulensis, Populus deltoides* and *Bombax ceiba.* Also in a study on clayey soil at Prabhunagar (Karnataka) the results have indicated that the maize fodder yield with *Dalbergia sissoo* (47.6 t/ha) was higher than other tree combination systems, but highest (73.2 t/ha) was recorded without trees (Anon, 1989).

But the mean seed yield of redgram (3.93 q/ha) under inter cropping situation with sissoo was less than that of redgram alone (5.14 q/ha) indicating low compatibility of redgram with sissoo as intercrop since the association of tree and crop might have competed for natural resources as both encompass large volume of soil.

However, the estimated gross returns during the year 1991 was found insignificant in sunflower, castor and redgram in association with sissoo, when compared to that of respective sole crops. Where as during the year 1992, significant differences were observed among the gross returns estimated both under intercropping and sole cropping. But the sunflower (Rs. 2,851) and castor (Rs. 3,159) in association with sissoo recorded more or less equal mean gross returns in comparison with that of sunflower and castor sole cropping (Rs. 2,914 and Rs. 3,106 respectively). Where as the redgram recorded the lowest returns (Rs. 2,360) under intercropping situation with sissoo when compared its performance with that of sole cropping (Rs. 3,084). The lower returns of redgram indicate its low compatibility with sissoo as intercrop since redgram being long duration and deep rooted crop.

(b) *Performance of D. sissoo trees in association with arable crops* : Tree growth in terms of height and girth was better in association with arable crops during both years of experimentation, except with redgram in the second year than that of sole sissoo (Table 2). During the first year, the increment in height of sissoo was more by almost twice under intercropping situation with all arable crops (sunflower, castor and redgram) than that of sole sissoo. The reasons for better growth in sissoo under intercropping situation with arable crops during the first year of experimentation might be due to its utilization of nutrients applied for the arable crops and also competition for the light from the associated crops. But in the second year, the increment in height of sissoo was slightly higher under intercropping situation with sunflower and castor than that of sole sissoo. Misra and Prasad (1980) observed no significant differences in growth of teak and sissoo during the first year of plantation both in

Table 1

Yields of arable crops in association with Dalbergia sissoo

Treatment	Seed yield (q/ha)			Gross returns (Rs/ha)		
	1991	1992	Mean	1991	1992	Mean
D. sissoo + Sunflower	4.94	3.83	4.38	3211	2490	2851
D. sissoo + Castor	6.72	3.00	4.86	4368	1950	3159
D. sissoo + Redgram	6.28	1.59	3.93	3765	954	2360
Sole Sunflower	4.81	4.15	4.48	3127	2701	2914
Sole Castor	6.44	3.11	4.77	4186	2025	3106
Sole Redgram	6.75	3.53	5.14	4050	2118	3084
CD at 5%	-	-	-	NS	378.7	-

Rates - Sunflower (Rs. 650/q), Castor (Rs. 650/q), Redgram (600/q)

Table 2

Growth of D. sissoo as affected by arable crops

Treatments	Increment in Height (cm)		Increment in Girth (cm)	
	1991	1992	1991	1992
Sole *D. sissoo*	88 (150-238)	87 (380-467)	5.5 (10.4-15.9)	5.7 (25.2-30.9)
D. sissoo + Sunflower	156 (150-306)	92 (328-420)	5.5 (10.2-15.7)	6.5 (20.4-26.9)
D. sissoo + Castor	180 (137-319)	97 (318-415)	5.8 (8.6-14.4)	6.6 (19.6-26.2)
D. sissoo + Redgram	180 (148-328)	59 (328-387)	5.6 (9.9-15.5)	4.7 (15.3-20.0)

The figures given in Parenthesis indicate the actual growth of *D. sissoo* before cropping and after cropping respectively.

control and in combination with short stratured crops like groundnut, til and soybean. however the rate of increment in height of sissoo was reduced when intercropped with redgram. This can be attributed to long duration and deep rooted nature of redgram which might have competed for available resources in tree association resulting in reduced height growth of sissoo.

The increment in girth of sissoo was more or less same in all the treatments during the first year of study, where as in second year the girth increment was decreased in sissoo associated with redgram as compared to that of sissoo associated with sunflower and castor and also of sole sissoo.

Since the growth of sissoo in terms of height and girth is very fast during the rainy seasons specially in the initial years because of its fast growing nature, hence the rate of increment was found very high during the year 1991 compared to that of year 1992.

(c) *Nutrient status of soil* : The organic carbon and soil nitrogen content was found to be increased by three folds in all the sissoo plots when compared to fallow plot after two years of plantation (Table 3). However sole sissoo plot recorded the highest organic carbon and soil nitrogen content when compared to intercropping situation. This may be attributed to the contribution of organic matter through the leaf fall of sissoo and its root mass and also its leguminous nature which might have helped in building up of soil nutrient status. Misra and Prasad (1980) also observed the significant effect of sissoo on soil with gain in N and P in the soil but a little decline in K.

Table 3

Nutrient status of soil in D. sissoo based cropping system

Treatment	Organic Carbon (%)		Organic matter (%)		Available Soil, Nitrogen (kg/ha)	
	1991	1992	1991	1992	1991	1992
Open area	0.22	0.21	0.39	0.36	104	107.8
Sole *D. sissoo*	0.26	0.64	0.45	1.10	146	382.5
D. sissoo + Sunflower	0.22	0.61	0.39	1.05	126	332.8
D. sissoo + Castor	0.20	0.61	0.34	1.05	124	332.4
D. sissoo + Redgram	0.23	0.61	0.40	1.05	138	358.4

SUMMARY

A field trial was initiated in the year 1991 on red sandy loam soils of Student's Farm, College of Agriculture, Rajendranagar, Hyderabad to study the compatibility of tree crop association in sissoo based agroforestry system under dry land situation. During two years of study (1991 and 1992), the yields of arable crops viz., sunflower, castor and redgram did not vary much in association with sissoo except during second year where the yields of redgram was reduced considerably. However, the mean yields of sunflower (4.38 q/ha) and castor (4.86 q/ha) when intercropped with sissoo where recorded on par with that of respective sole crops (4.48 and 4.77 q/ha respectively). The gross returns were also found higher in sunflower and castor crops under intercropping as well as sole cropping when compared to that of redgram. The associated crops did not exert any inimical effects on growth of sissoo. But the rate of increment in growth of sissoo was decreased to some extent in association with redgram. Growing sissoo trees proved beneficial specially in improving the site by increasing organic carbon and nitrogen substantially as compared to fallow land. The results revealed that growing of sissoo in association with arable crops provides sustainability to the traditional arable farming in dry regions.

दीर्घकालिक वर्षा पोषित खेती के लिए कृषि फसलों के साथ बीच में *डलबर्गिया सिस्सु* लगाने की सुसंगतता

एम०वी०आर० सुब्रह्मण्यम, जी० भीमैय्या व सैय्यद इस्माइल

सारांश

कृषि महाविद्यालय, राजेन्द्रनगर, हैदराबाद (आन्ध्रप्रदेश) के विद्यार्थी फार्म में शुष्क दशाओं में शीशम को आधार स्वरूप लेकर कृषिवानिकी प्रणाली के अन्तर्गत फसल साहचर्य में वृक्ष सस्य की सुसंगता का अध्ययन करने के लिए लाल रेतीली टुमट मृदाओं में एक क्षेत्र परीक्षण 1991 में शुरू कराया गया। दो वर्षों (1991 व 1992) के अध्ययन के दौरान कृष्य फ़सलों अर्थात् सूरजमुखी, परंड और लाल चने की प्राप्ति में शीशम को साथ रखने पर कोई खास अन्तर नहीं पड़ा सिवाय इसके कि दूसरे वर्ष में लाल चने की प्राप्ति में काफी कमी हो गई। तथापि सूरजमुखी (4.38 ग्रा/हेक्टे०) और एरंड (4.86 ग्रा/हेक्टे०) की माध्य प्राप्ति जब उन्हें शीशम के साथ बोया गया तो वह उन्हें अकेले उगाने के (4.48 और 4.77 ग्रा/हेक्टे० क्रमशः) बराबर ही रही। तथापि चने के साथ तुलना करने पर सूरजमुखी और एरंड की सक्ल प्राप्ति उन्हें अकेले उगाने की तुलना में साहचर्य में उगाने पर अधिक ही पाई गई। साहचरी फसलों का शीशम की वृद्धि पर कोई प्रतिकूल प्रभाव नहीं पड़ा। किन्तु चने के साथ लगाने

पर शीशम के बढ़ने की संवृद्धि दर में थोड़ी सी कमी आई । शीशम के वृक्ष लगाना लाभप्रद भी रहा विशेषकर जमीन परती छोड़ने की तुलना में जैव कार्बन और नाइट्रोजन काफी मात्रा में बढ़ने पर स्थल में हुए सुधार के कारण । परिणामों से पता लगा कि कृष्य फसलों के साथ शीशम को उगाने से शुष्क प्रदेशों में पारम्परिक कृषि को दीर्घ काल तक चलते रहने की क्षमता प्राप्त होती है ।

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EFFECT OF FOREST TREE SPECIES ON THE YIELD POTENTIAL OF INTERCROPS

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Introduction

Not only does intercropping increase the crop yield and net profit, but it also curtails the cost of cultivation. It also helps in minimizing the problems of weed, pest and disease management to some extent.

The choice of tree species depends upon climatic and edaphic conditions, maturity cycles, compatibility with agricultural crops, local demands, prices of wood in nearby markets and the illicit felling by unsocial elements (Dwivedi, 1992).

No serious attempts seem to have been made in Gujarat or elsewhere to obtain or to determine economical intercrops in widely-spaced forest tree species. The present investigation was therefore, aimed to assess the intercropping of agricultural crops in widely-spaced forest trees with prime objective to study the effect of forest tree species on the yield potential of intercrops.

Materials and Methods

The study was conducted during the year 1994-95 on the farm of Aspee College of Horticulture and Forestry, Gujarat Agricultural University, Navsari Campus, Navsari.

The main plot treatments comprised of five-year-old three forest tree species viz., *Casuarina equisetifolia* L. (*Casuarina* - F_1), *Adina cordifolia* Benth. and Hook. f. (Haldu - F_2) and *Gmelina arborea* Roxb. (Sivan - F_3). They were planted at 10 m x 2.5 m spacing and subplot treatments constituted three different agricultural crops viz., *Cicer arietinum* L. (Gram - C_1), *Brassica Juncea* L. (Mustard - C_2) and *Dolichos lablab* L. (Indian bean - C_3). Above twelve treatment combinations were tried in split plot design with four replications. The recommended varieties and practices were used to raise the intercrops.

The light intensity was measured by using the digital Lux meter in each treatment. As the number of observations under different treatments varied 't' test was applied for comparing the treatment means.

Results and Discussions

Crop yields : The effect of forest tree species was found significant in affecting yield attributes viz., grain yield per plant, grain yield per plot and per hectare (Table 1).

Table 1

Grain yield of agricultural crops as influenced by different forest tree species.

Species		Agricultural crops		
		Gram (C$_1$)	Mustard (C$_2$)	Indian bean (C$_3$)
Grain yield per plant (g)				
Control	(F$_0$)	4.73	8.32	7.58
Casuarina	(F$_1$)	3.65	6.93	6.17
Adina cordiflora (Haldu)	(F$_2$)	4.37	7.81	7.12
Gmelina arborea (Sivan)	(F$_3$)	4.68	7.98	7.33
Grain yield (kg/plot)				
Control	(F$_0$)	1.90	1.55	1.41
Casuarina	(F$_1$)	1.49	1.29	1.15
Adina cordifolia (Haldu)	(F$_2$)	1.85	1.45	1.33
Gmelina arborea (Sivan)	(F$_3$)	1.87	1.48	1.36
Grain yield (kg/ha)				
Control	(F$_0$)	1755.56	1432.64	1306.25
Casuarina	(F$_1$)	1377.79	1193.98	1063.66
Adina cordifolia (Haldu)	(F$_2$)	1710.65	1345.60	1228.70
Gmelina arborea (Sivan)	(F$_3$)	1733.33	1375.00	1259.95

The grain yields of gram (C$_1$), mustard (C$_2$) and Indian bean (C$_3$) crops were significantly higher under control in open field (F$_0$) than those grown in association with trees. Sharma *et al.* (1994) also observed similar reductions in yields of pearlmillet and clusterbean crops grown under tree species.

The greater reduction in yields under *Casuarina* (F$_1$) than Haldu (F$_2$) and Sivan (F$_3$) might be due to its higher canopy diameter which resulted in decrease in incoming radiation to agricultural crops underneath (Table 2). Allelopathic effects of *Casuarina* on growth of intercrops could also be another plausible factor responsible for the observed decrease in yields. These findings tally with those reported by Patel (1994).

Light intensity : The data presented in Table 2 indicated that appreciably the lowest light intensity was observed under F$_1$ (*Casuarina*), whereas the highest with F$_0$ (control in open field). This is due to spreading branches, height and higher crown diameter of F$_1$ as compared to others. It might be due to characteristics of the tree species. The sharp decrease in the total and

Table 2

The light intensity (Kilolux) of different forest tree species as influenced by agricultural crops

Species		Distance from the tree (m)		
		0.5 m (d_1)	1.5 m (d_2)	2.5 m (d_3)
Control	(F_0)	472.77	472.77	472.77
Casuarina	(F_1)	190.22	238.63	265.70
Adina cordifolia (Haldu)	(F_2)	250.20	296.68	330.40
Gmelina arborea (Sivan)	(F_3)	296.60	354.50	378.80

net radiation energy was noticed under F_1. Light intensity beneath *Casuarina* indicated poor light condition for the growth of agricultural crops underneath. This is in conformity with Singh (1986).

SUMMARY

The present investigation was carried out with its prime objective to study the effect of forest tree species on the yield potential of intercrops during the year 1994-95. Grain yield of agricultural crops (intercrops) grown in association with trees decreased compared to sole crops. The reductions in yields under *Casuarina* were more than *Adina cordifolia* and *Gmelina arborea*. Maximum light intensity was recorded under open field (control) while it was found to be minimum with *Casuarina*.

अर्न्तफसलों की प्राप्ति संभाविता पर वन वृक्ष जाति लगाने का प्रभाव

के०बी० मेहता, एम०यू० मुकाडिया, बी०जी० वाशी व डी०बी० जडेजा

सारांश

प्रस्तुत अन्वेषण मुख्यतः 1994-95 के दौरान अर्न्तफसलों की प्राप्ति संभाविता पर वन वृक्ष जातियों के प्रभाव का अध्ययन करने के लिए कराया गया है । कृषि फसलों (अर्न्तफसलों) की अन्न प्राप्ति, जिन्हें वृक्षों के साथ उगाया गया, अकेले उगाए जाने की तुलना में घट गई । *कैजुआरिना* के साथ लेने पर यह घटत *एडिना कोर्डिफोलिया* और *ग्मेलिना अर्बोरिया* को साथ लेने पर हुई घटत के मुकाबले में ज्यादा रही । अधिकतम प्रकाश चण्डता खुले खेतों (नियामक) में अभिलिखित हुई जबकि *कैजुआरिना* लेने पर यह चण्डता सबसे कम पाई गई ।

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INFLUENCE OF *EUCALYPTUS* SHELTERBELT ON FODDER CROP (*SORGHUM VULGARE*)

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Introduction

Farm forestry is an age old practice in the rural areas of Northern India. Field windbreaks/shelterbelts are one method for increasing per unit area productivity for the producer and simultaneously enhancing environmental quality for the benefit of society.

The tree crop interaction influences agricultural production to varying degrees depending upon species and system of cropping. Systematic attempts to evaluate such existing agroforestry practices under varying site conditions and efforts to improve them for higher productivity and better economic gains have been lacking. The present work describes a field experiment in which the performance of *Sorghum vulgare* cultivated for fodder was observed when grown in combination with *Eucalyptus* hybrid plantation raised in single row on one side of the field.

Materials and methods

Plantation of *Eucalyptus tereticornis* (nearly 6 year old) situated about 15 km from Roorkee in District Haridwar was selected. Soils of the plots were sandy loam to loam. The experimental plots were sown with *Sorghum vulgare* during 1987, Kharief season. Top dressing of 15 kg Urea was done in each plot in two split doses. The boundary plantation consisting tree line were growing along the northern and western boundary of the fields in East-West and North-South directions, respectively. In each plot the other three sides had no trees and thus considered as open borders. The experimental plots were flood irrigated thrice during the growing season. The experimental area in each plantation measured 26m x 20m. To study the influence of tree line on chari crop, following twelve sample plots were laid at varying distances on lines running perpendicular to the tree line and replicated three times. Each of the 36 sample plot units measures 1 m x 1 m.

Distance (m) : 0.5, 1.5, 2.5, 3.5, 4.5, 5.5, 6.5, 7.5, 8.5, 9.5, 10.5, 11.5.

The perpendicular lines were spaced at 8 m and 15 m from either side of open borders towards the centre of tree line. For the purpose of analysis of variance the sample plots were pooled into four distance treatments viz, upto 3 m (T1), 3 m to 6 m (T2), 6 m to 9 m (T3) and above 9 m (T4) with three replications. The farthest plots (T4) in each field were treated as control.

The following data were recorded in each sample/plot

(i) Number of *Sorghum* plants.
(ii) Crop height.
(iii) Yield (green weight per m^2).
(iv) Height, girth at breast height (GBH)

Table 1

Crop data of Sorghum vulgare (chari) when grown with single row boundary plantation of Eucalyptus hybrid

Distance	Fodder yield (q/ha) (green weight)		Plant density (Number/m^2)		Mean height of of chari plants(m)	
Tree line direction : Plot position :	E-W Plot on South	N-S Plot on West	E-W Plot on South	N-S Plot on West	E-W Plot on South	N-S Plot on West
T1 (upto 3 m)	201.85	262.89	43.11	32.77	2.17	2.30
Net loss in affected area (78 m^2)	0.92q	2.89q	8.45/m^2	11.90/m^2	0.75m/ plant	0.99m/ plant
Decrease over control (%)	36.82	58.52	16.39	26.64	25.68	32.15
T2 (3 m to 6 m)	251.39	531.444	44.33	42.00	2.57	3.03
Net loss in affected area (78 m^2)	0.53q	0.81q	7.23nos/m^2	2.67nos/m^2	0.351m/ plant	0.36m/ plant
Decrease over control (%)	21.35.	16.27	14.02	5.98	11.98	10.62
T3 (6 m to 9 m)	318.89	548.56	49.56	40.22	2.67	3.14
Net loss in affected area (78 m^2)	0.0055q	0.66q	2 nos/m^2	4.45nos/m^2	0.25m/ plant	0.25m/ plant
Decrease over control (%)	0.22	13.41	3.88	9.96	8.56	7.37
T4 (Above 9 m)	319.67	634.22	51.56	44.67	2.92	3.39
Net loss	00	00	00	00	00	00
Decrease over control (%)	00	00	00	00	00	00
Affected area (234 m^2) upto 9 m	-	-	-	-	-	-
Net loss in affected area (234 m^2)	1.47q	4.35q	5.89nos/m^2	6.33nos/m^2	0.45m/ plant	0.57m/ plant
Decrease over control (%)	19.61	29.33	11.42	14.18	15.41	16.81
SEM (±)	18.2123	46.6741	NS	NS	0.0809	0.1285
CD at 5(%)	52.4908	134.5227			0.2333	0.3682

and crown width of all *Eucalyptus* trees.

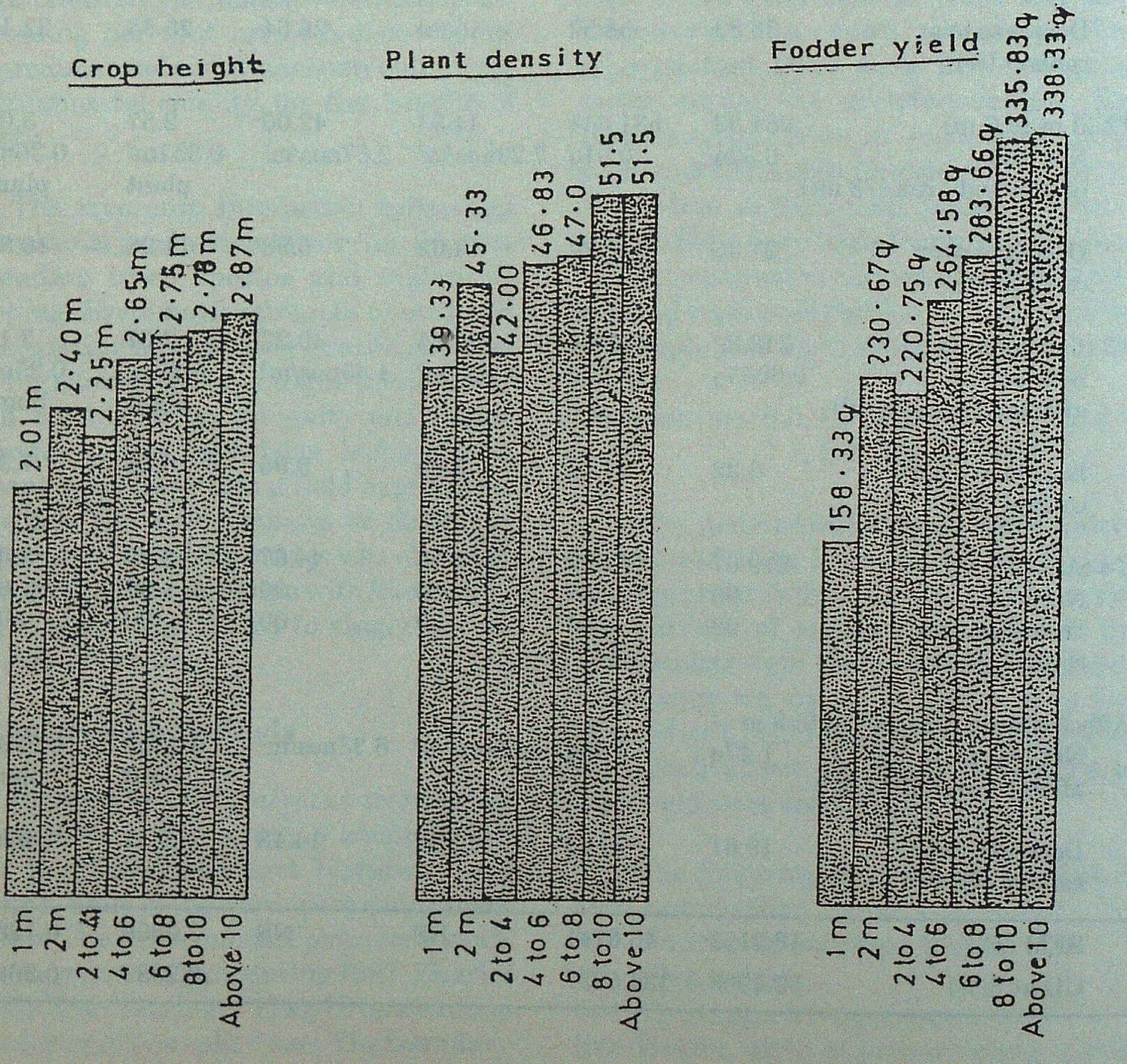
To estimate the extent of variation in fodder yield due to tree line at various distances from tree line and also from either side of open boundaries, a regression equation was developed using the mean fodder yield data of each sample plot unit.

Results

Fodder yield (green weight per m^2), height growth and plant population density (plant number per m^2) as affected by *Eucalyptus* hybrid tree line are given in Table 1.

Fodder yield : Fodder yield of *Sorghum* (chari) crop showed a strong positive relationship with distance from tree line (Table 1). Fodder yield in the vicinity of trees was significantly (1% level) less upto 6m distance from East-West tree line than those beyond 9 m while in North-South tree

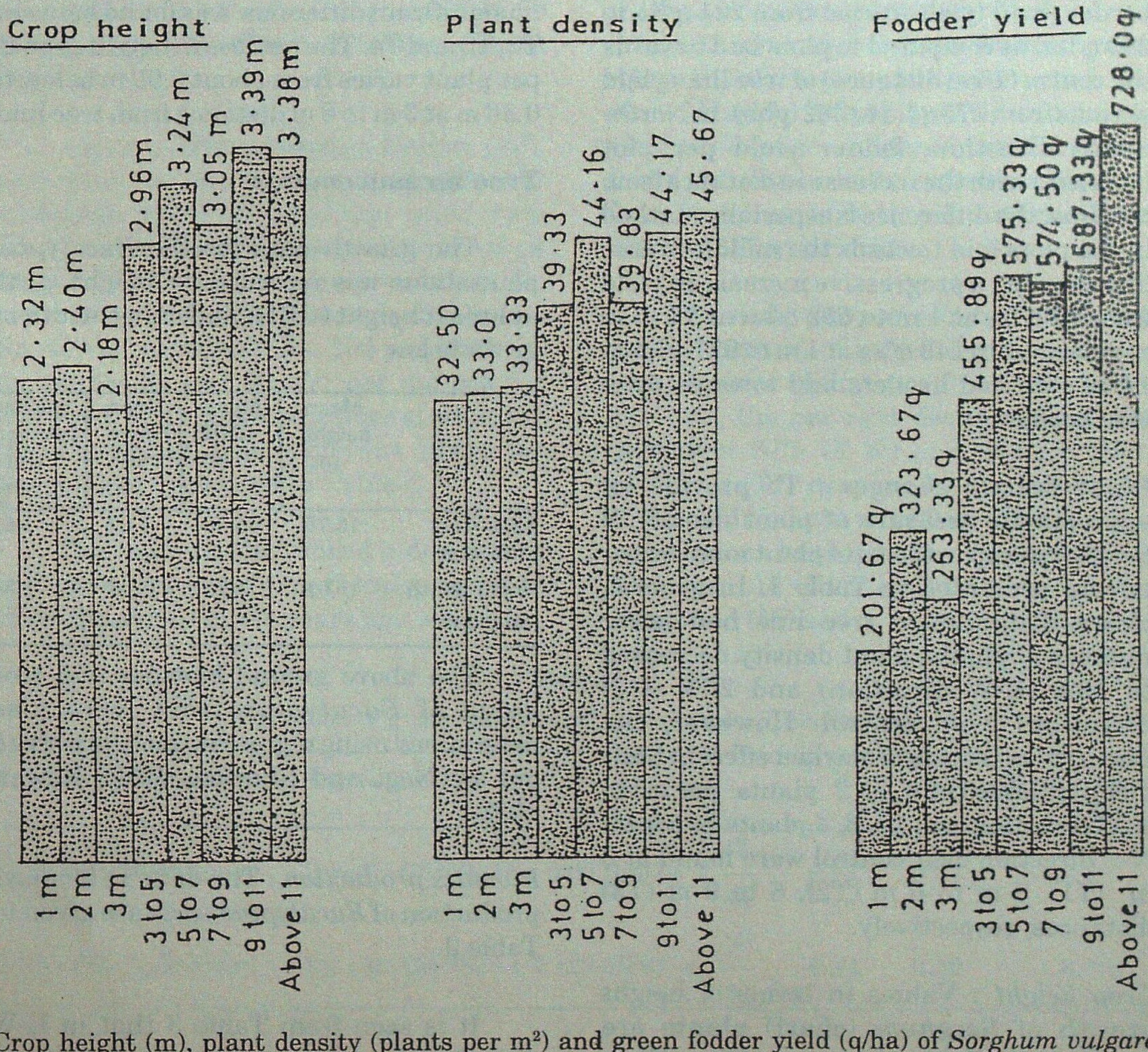
Fig. 1



Crop height (m), plant density (plants per m^2) and green fodder yield (q/ha) of *Sorghum vulgare* cultivated in combination with *Eucalyptus* hybrid boundary plantation grown on East-West direction.

line it declined significantly upto 3 m (T1) only. The percentage losses and net losses compared to farthest plots (T4) have been examined to compare the results of two fields. When compared to farthest plots (above 9 m) of E-W direction, fodder yield was about 36% less at the closest spacing (upto 3 m) from tree line closely followed by 21% at 3 m to 6m spacing and similarly for the N-S tree line were 58% and 16% respectively. Fodder yield at 6 m to 9 m distance although showed a decreasing trend but the relative differences were smaller. Thus the total affected area due to tree line works out 234 m^2 (Table 1) and the net losses estimated to 1.47 q (19.61%) and 4.35 q (29.33%) in the plots cultivated with plantations grown on E-W and N-S directions respectively. Fodder yield (kg) data per m^2 at different distances from tree line have been depicted in Fig. 1 (E-W) and Fig. 2 (N-S).

Fig. 2



Crop height (m), plant density (plants per m^2) and green fodder yield (q/ha) of *Sorghum vulgare* cultivated in combination with *Eucalyptus* hybrid boundary plantation grown on North-South direction.

The mean yield data from all sample plots is considered and a regression of yield data over distance was carried out. The regression equations so derived are given in Table 2.

It is seen (Fig. 3 and 4) that in East-West direction, fodder yield declined with closer distance to tree line, namely from about 289 q/ha at 14 m to 125 q/ha at 1 m distance from tree line. There was very little difference between fodder yield data estimated in plots laid towards open side border (8 m) (yield varied from 221 q/ha to 289 q/ha) as compared to plots laid towards the centre (15 m distance) of tree line (yield various from 175 q/ha to 282 q/ha). In North-South direction, fodder yield per plot increases with the increase in distance from tree line, the difference is especially marked in the plots laid towards the middle of tree line showing a progressive increase in yield from 75 q/ha at 1 m to 652 q/ha at 14 m in comparison to 143 q/ha at 1 m to 927 q/ha at 14 m obtained in plots laid towards open side borders.

Plant density changes : To provide an approximate measure of plant density of *Sorghum* crop in terms of plant number per m^2 are presented in Table 1. In general, closer distances to tree line had lower number of plants, plant density decreased to 16% (E-W direction) and 26% (N-S direction) over control. However, the *Eucalyptus* trees had marked effect in their vicinity, losses of 8, 7, 2 plants per m^2 in E-W direction and 12, 6, 4 plants in per m^2 N-S direction over control were found at 3 m (T1), 3 m to 6 m (T2), 6 to 9 m (T3) distances, respectively.

Crop height : Values in terms of height growth of *Sorghum* (chari) plants are presented in Table 1. In case of East-West direction, chari plants grew significantly (1% level) poor upto 3 m (T1) distance from tree line than those at long distance treatments (T4). No significant difference was found in height growth between T2 (3 m to 6 m) and T3 (6 m to 9 m) treatments. Height increment declined by about 26% nearest to the tree line (T1) giving a net loss of about 0.75 m per plant. In North-South direction, crop height declined still more (32%) significantly (1% level) at closer distance i.e. below 3 m (T1) in comparison to plant height beyond 9m (T4). However, no significant difference was found between T2, T3 and T4. The net loss in height growth per plant varies from about 0.99 m below to 0.36 m at 3 m to 6 m distance from tree line.

Tree measurements

The growth data for the *Eucalyptus* plantations was recorded for height, girth at breast height (GBH) and crown width as given below :

	Mean height (m)	Mean GBH (cm)	Mean crown width (m)	Spacing between trees (m)
East-West direction	15.75	46.43	1.62	1.63
North-South direction	16.01	45.0	1.68	1.34

The above ground biomass and tree value of *Eucalyptus* trees were also determined using regression models worked out by Negi and Sharma, 1987; Rawat, 1988.

Biomass production : The data on biomass production of *Eucalyptus* trees are given in Table 3.

It is seen from Table 3 that in E-W direction the total above ground biomass per tree was lowest i.e. 54.635 kg and it continued to exhibit an appreciable ascending trend in higher diameter classes giving 77.10 kg, 126.43 kg and 150.56 kg. Bole wood is considered to be commercially important, it contributed about 70% in higher diameter class (above 15 cm) and about 60% in below 15 cm diameter class. In North-South direction the total above ground biomass production was the lowest (39.40 kg/tree) in lower diameter class which include only 3 trees. Maximum number of trees fall under diameter class above 14 cm contributing biomass of the order of 71 to 129 kg/tree. The bole alone contributed about 67 to 69 per cent per tree of the total above ground biomass.

Tree value : The estimated timber (m^3), pulpwood (m^3 stack), fuelwood (qtl) and stumpage value of individual trees were determined. Tree value was considered on the basis of market prices reduced for harvesting costs. The rates adopted were : Rs. 400/m^3 for timber Rs. 150 per stack m^3 for pulpwood and Rs. 50 per quintal for fuelwood. The estimated values of standing trees grouped into different diameter classes, are presented in Table 4.

The estimates in Table 4 indicate that the gross income from *Eucalyptus* trees (E-W direction) at six years age works out to Rs. 524.33 for 15 trees per 26 m tree line and Rs. 2144.51 for 61.35 trees per 100 m tree line or Rs. 357 per year. In case of N-S direction the gross income from 19 trees was estimated to Rs. 610.98 for 26 m tree line and Rs. 2399.87 for 74.63 trees per 100 m tree line or Rs. 400 per year.

Discussion

The results presented in Table 1 on fodder yield, plant density and height revealed that the losses to all crop parameters in the vicinity of tree line were exceptionally higher in the plots cultivated with plantations grown on North-South direction compared to East-West direction where the effect was not so pronounced. The plant density, height growth and fodder yield of *Sorghum vulgare* (chari) crop was found to increase with increase in distance from tree line in both plantations (East-West and North-South.

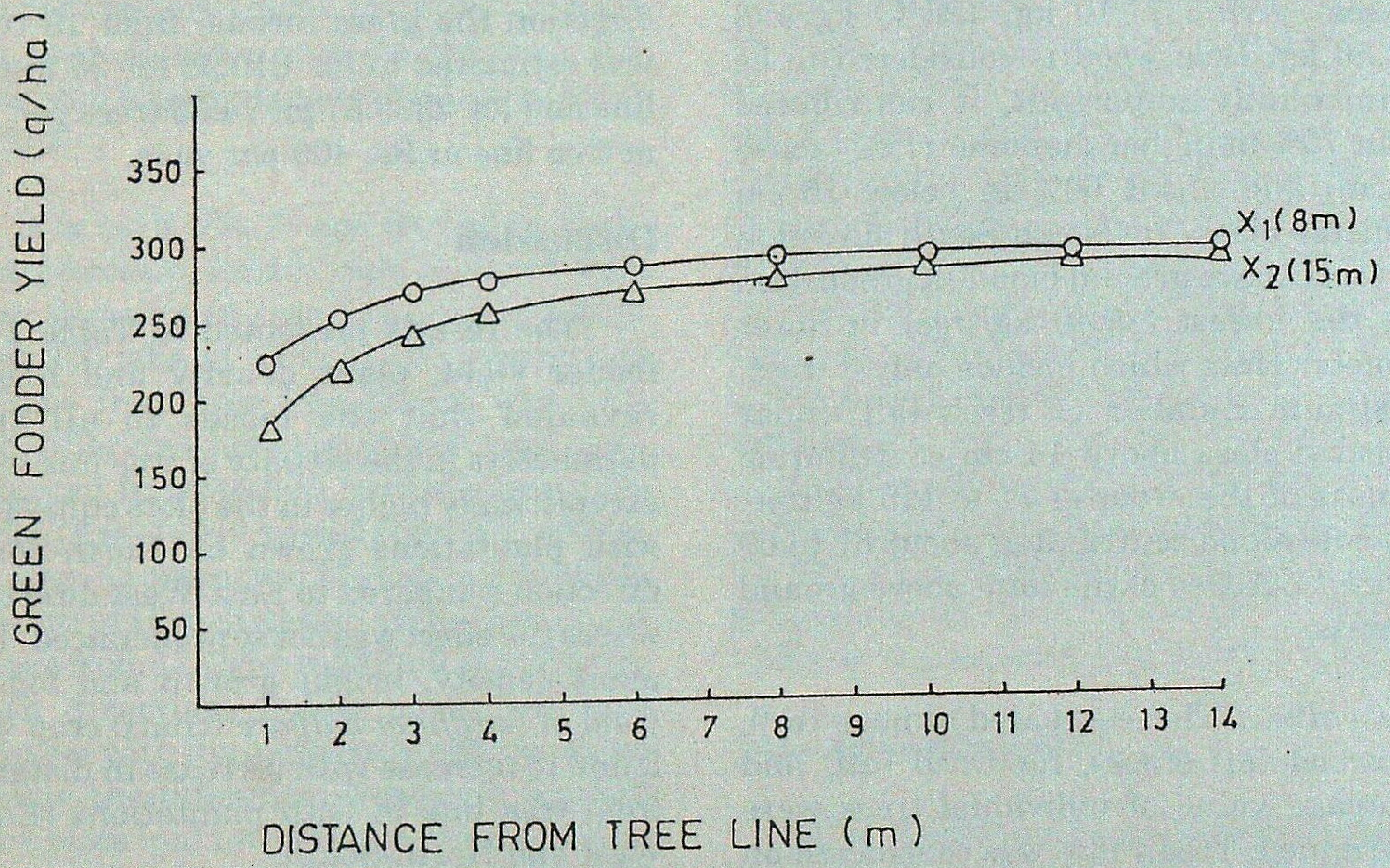
The chari crop evaluated showed a general pattern of increasing fodder yield with increase in distance from *Eucalyptus* tree line, the per cent decline which was maximum 37% (E-W) and 58.52% (N-S) upto 3 m (T1) dropped to approximately 21% and 16% at 3 m to 6 m (T2). Similar observations have also been recorded in a 23 year old *Eucalyptus tereticornis* plantation (Prasad *et al.*, 1985). The yield

Table 2

Regression of green fodder yield over distance from tree line

Type of Plantation	Regression equation	R^2	R	Significance level
East-West direction	$1/y = 0.003369027 + 0.00014472 \times \frac{x2}{x1}$	0.41	0.64	0.1%
North-South direction	$1/y = 0.06233828 + 0.12749581 \times \frac{x2}{x1}$	0.24	0.49	0.1%

Fig. 3



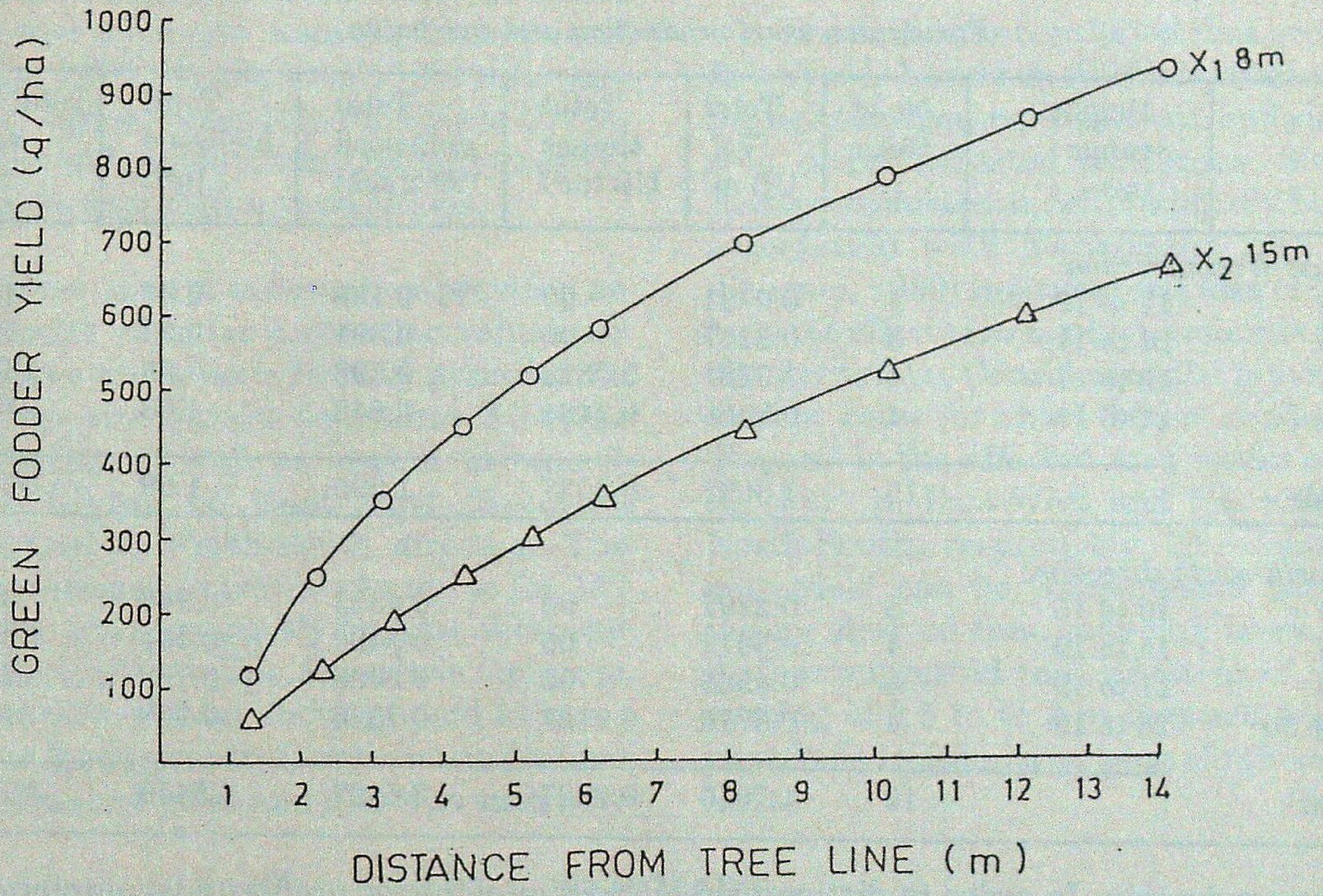
Effect of *Eucalyptus* hybrid tree line (East-West direction) on green fodder production (q/ha) of *Sorghum vulgare*.

Table 3

Total above ground biomass

Diameter class	Tree height range (m)	No. of trees	Above ground biomass (dry kg)					
			leaf	Twig	Branch	Bark	Bole	Total
(a) *East-west direction*								
10-12	11 to 19	4	15.03	12.27	27.82	29.07	134.35	218.54
12-15	12 to 17	6	28.93	23.12	53.84	58.54	298.17	462.60
15-18	16 to 18	2	13.71	10.61	25.47	29.61	174.03	253.43
Above 18	13 to 17	3	23.24	17.77	43.20	51.30	316.10	451.69
Total		15	80.91	63.77	150.33	168.52	922.73	1386.26
(b) *North-south direction*								
10-12	10 to 14	3	8.88	7.42	16.44	16.46	69.01	118.21
12-14	14 to 17	5	22.73	18.25	42.12	45.53	226.66	355.29
14-16	11 to 19	7	40.47	31.78	75.08	84.68	464.52	696.53
Above 16	16 to 19	4	27.80	21.49	51.64	60.09	353.55	514.57
Total		19	99.88	78.94	185.28	206.76	1113.74	1684.60

Fig. 4



Effect of *Eucalyptus* hybrid tree line (North-South direction) on green fodder production (q/ha) of *Sorghum vulgare*.

of rainfed black gram, green gram and *Sorghum* get affected upto 5 m distance and this affect is considerably reduced after 10 m distance from tree line. Studies conducted on wheat cultivated in association with *Acacia nilotica* and *Eucalyptus* hybrid boundary plantations Sharma, 1990, 1992 also showed similar trend. The growth performance of all crop parameters of *Sorghum* crop declined sharply between 2 m and 4 m distances (Fig. 1 and 2) which indicate a strong negative interaction between *Eucalyptus* tree and *Sorghum* crop. On an average the *Sorghum* crop showed an increase in plant number from closure distance to farthest plots from tree line would indicate a more than sufficient reproduction rate and a fall in plant number towards tree line appears to be due to poor germination and subsequent death of plants. The crop height data indicate that increase in distance from tree line showed an increase in height growth of *Sorghum* plants which were greatly affected near tree line (32% in N-S direction and 26% in E-W direction). However, in both plots (E-W, N-S) the general trend has been for wider distances from tree line to produce taller plants.

Although the height growth and plant density data provides an indication of tree line effect, it is the fodder production values per unit area that are of most significance. The decline in plant number (density) and loss in height growth preclude the green

Table 4

Eucalyptus wood production and tree value

Girth class (cm)	Height range (m)	No.of trees	Total Vol. UB m^3	Total timber UB (m^3)	Total pulpwood (m^3 stack)	Total fuelwood (qtl)	Total tree value (Rs.)
(a) *East-West direction*							
30-40	11 to 19	4	0.0701	00	0.158	0.08	34.05
40-45	14 to 17	3	0.2147	00	0.391	0.33	75.30
45-50	12 to 17	4	0.3281	0.0513	0.598	0.50	135.22
Above 50	14 to 18	4	0.7568	0.2464	0.848	1.08	279.76
Total		15	1.3697	0.2977	1.995	1.99	524.33
(b) *North-south direction:*							
30-40	10 to 15	5	0.2297	00	0.4323	0.348	82.25
40-45	15 to 19	4	0.3012	00	0.5490	0.464	105.56
45-50	11 to 19	6	0.4985	00	0.9088	0.769	174.78
Above 50	16 to 19	4	0.6716	0.2187	0.7526	0.960	248.39
Total		19	1.7010	0.2187	2.6427	2.5410	610.98

fodder production. In order to distinguish between causes, spacing between trees and crown width of trees were recorded. The crown width for North-South tree row was found to be 1.68 m and for East-West tree row 1.62 m, respectively. The crown spread check the light intensity available to crop plants. It was observed that the leaf litter which fall on the ground spreads upto 4 m distance from tree line, maximum being on area between 1.5 m to 3.5 m. This factor could be responsible for poor performance of *Sorghum* crop between 2 m to 4 m, compared to even the closest distance below 2 m. Although *Sorghum* crop may be suppressed from other factors like root competition for moisture and nutrients and alletopathic affect of tree leaf litter. The work on the rooting pattern and root interaction of woody species have been reviewed by many workers (Jenik, 1977; Kerfoot, 1963) indicate that largest number of roots and majority of fine roots of many woody species are located in the upper fertile portion of the soil profile under agroforestry conditions. Rooting depth and root spread of *Eucalyptus* and Maize crop under irrigated conditions in the adjoining area was studied (Sharma, 1990). According to this study, majority of maize roots were concentrated upto 20 cm depth and their spread was reduced thereafter. Whereas the tree feeder roots were concentrated in 45-65 cm depth zone at 2.5 to 2.9 m from tree row. Root densities of Maize and *Eucalyptus* trees examined by trench intersect method at a depth of 40 cm 4 m away from tree line were found to be 0.008 cm/cm^3 for maize crop and 0.005 cm/cm^3 for *Eucalyptus* trees which is considered to be insignificant. Repeated cultural operations particularly ploughing in agricultural fields restrict also the distribution and spread of tree roots in the rhizosphere of agricultural crops and thus the effect of tree and crop root interaction alone on the yield reduction of *Sorghum* is not significant. Allelopathic effect of *Eucalyptus* leaf litter due to presence of leachates in the leaves inhibiting seed germination of cereal crops have been reported by many workers (Saxena and Singh, 1978; Sharma *et al.*, 1987; Sharma, 1992) under laboratory conditions but its impact under field conditions (agroforestry) requires thorough investigations.

Tree growth information provides an indication of better production values per unit area under farm forestry practices. In the present study the total biomass production as well as annual increment were higher in East-West direction compared to North-South direction. The gross income per tree works out to Rs. 137 and Rs. 134 respectively for East-West and North-South tree line. Since Bole represent about 67% of total above ground biomass and as *Eucalyptus* trees are in much demand for ballis and poles and if sold as such may certainly fetch more price.

It can thus be concluded that growing *Eucalyptus* hybrid on field boundaries has negligible impact on the growth and yield of crop under irrigated conditions. Similar studies conducted on cultivation of wheat in association with *Eucalyptus* tree line (Sharma, 1990) indicated net loss of 24.96 kg in the affected area which amounts to Rs. 60/- per season. Considering the prevailing market rates for chari fodder the loss in 'Rupees' in the affected area works out to Rs. 100/- in East-West and Rs. 169/- for North-South, respectively. The losses in crop yield can be compensated through income derived from standing trees. It is further suggested that adoption of wider spacing of 2.5 m to 3 m between trees is expected to minimize or even eliminate the losses.

SUMMARY

In Northern India, use of *Eucalyptus* as windbreak/shelterbelt is well accepted but questions concerning the economic impact on crop production system requires through investigations. In this study, the influence of *Eucalyptus* trees on agriculture crop viz., *Sorghum vulgare* in terms of plant density, crop height and fodder yield were found negative in the vicinity of tree. Gross income from *Eucalyptus* trees for 100 m tree line estimated to Rs. 2144 for 61.35 trees in east-west and Rs. 2399.87 for 74.68 trees in north-south tree line. It was concluded that growing *Eucalyptus* on field boundaries under irrigated condition had very little impact on associated *Sorghum* crop and the crop losses due to tree line are well compensated by the income received out of sale of trees.

युकेलिप्टस की आश्रय पट्टी का चारे की फसल *सोरधम वल्गारे* पर प्रभाव

के०के० शर्मा, प्रदीप खन्ना व अजय गुलाटी

सारांश

उत्तरी भारत में *युकेलिप्टस* को वायुअवरोध, आश्रय पट्टी के रूप में अपनाया गया है किन्तु इसके फसल उत्पादन पर आर्थिक प्रभाव की भली प्रकार अनुसंधान की आवश्यकता है । इस अध्ययनन में *युकेलिप्टस* का प्रभाव कृषि उपज जैसा कि *सोरधम वल्गारे* पर पौधे का घनत्व, फसल की ऊँचाई तथा चारे की अनुकूल उपज वृक्षों के आस-पास में नकारात्मक पाई गई । कुल आय *युकेलिप्टस* वृक्षों के 100 मी० वृक्ष रेखा रू० 2,144, पूर्व-पश्चिम में 61.35 और 74.68 वृक्षों पर उत्तर-दक्षिण वृक्ष रेखा में रू० 2399.8७ आंकी गई । इससे पता चलता है कि *युकेलिप्टस*, खेत मेढ़ों में सिंचाई वाली का बहुत कम समधात *सोरधम* की फसल पर पड़ा तथा फसल हानियों की क्षतिपूर्ति वृक्ष रेखा के विक्रय द्वारा हुई आमदनी से हुई ।

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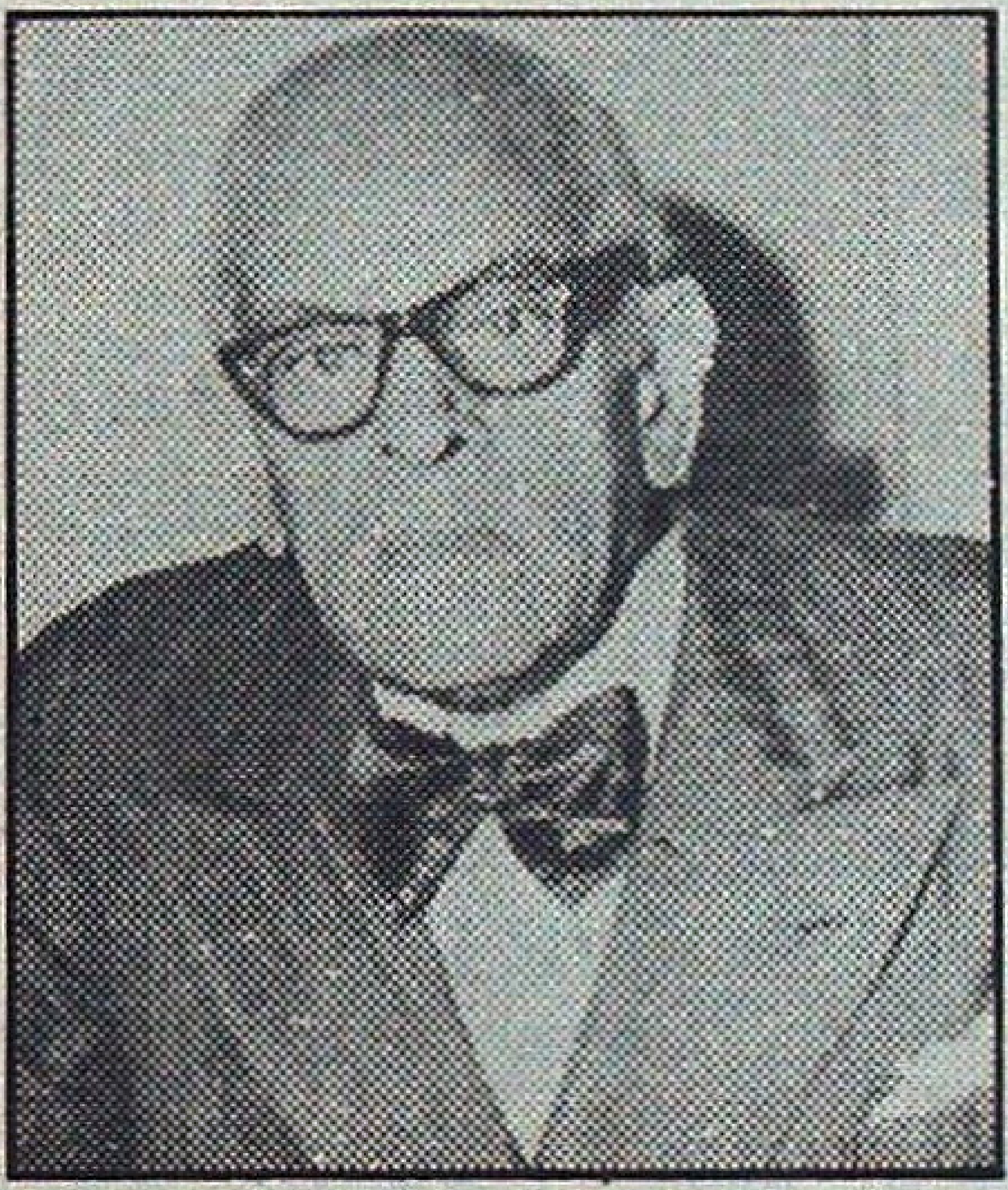
OBITUARIES

(I)

G.G. Takle

(14.9.1901 - 26.2.1996)



Shri G.G. Takle, retired Inspector General of Forests, passed away at Pune on 26th February 1996 at the age of 94, after a brief illness. He was the Chief Conservator of Forests at Nagpur in the erstwhile Madhya Pradesh.

Born in Dhule on 14.9.1901, he was brought up by Shri. S.S. Deo, a well known 'Samartha Bhakta', having lost his father at an early age. He joined the Fergusson College in 1918 and graduated in 1922. He was also a Fellow in the College in Pune for a year before proceeding to Cambridge for higher studies for the Indian Forest Service. He returned to India in the year 1925 and was posted as Junior Forest Officer at Raipur. Later, he was posted as the D.F.O. at Chanda (present Chandrapur) where he contributed a great deal in development and management of teak plantations of Alapally. He rose rapidly to become the Chief Conservator of Forests in 1953 at Nagpur until 1956 when he was appointed as the Inspector General of Forests, the top post in the I.F.S. cadre at New Delhi. He left his imprint on the working of the Forest Research Institute and Colleges. Upon his retirement in 1958, he was appointed as the Timber Expert on the Railway Board for two years. He had settled down in Pune in 1961.

He was awarded the Order of the British Empire in 1946 for his distinguished contribution to conservation of forests and afforestation in India. He was fondly referred to as "Maharshi". He placed professional ethics and integrity high on the list of priorities in life. Of particular interest to him was guiding and nurturing the professional and personal lives of young officers. He had a phenomenal memory for names and places, which endeared him to one and all when he addressed them by their first names and enquired feelingly about their well-being.

During his career as a Forester, he worked on several Forest Plans in Chandrapur, Bastar and Melghat areas. He travelled extensively in India and abroad to England and other parts of Europe, Indonesia and Australia. He was responsible for many prestigious projects like the Bhilai Steel Plant and the Nepa Paper Mills. He was

Contd...

an Officer on Special Duty when the Princely States of Chhattisgarh, Bundelkhand and Baghelkhand were merged in the then Madhya Pradesh soon after Independence. He took up the Chairmanship of PAPCO Ltd. after his retirement from Government Service and was later instrumental in setting up the Central Pulp Mills at Songarh in Gujarat State.

While in Nagpur, he was a regular Bridge player in the Gondwana Club in able partnership with his wife Smt. Shantabai Takle and won several matches and medals. An experienced Shikari, he collected several trophies including tigers and panthers. He also took keen interest in Cricket and Tennis.

He led a peaceful retired life and continued his morning walk and played Bridge regularly at the Deccan Gymkhana. Revered and respected by his juniors as the doyen of Indian Forestry, he was self-disciplined and an astute Government Servant.

He leaves behind his wife Smt. Shantabai Takle, 86 years of age, after a happy married life of 73 years; his son Shri N.G. Takle General Manager (Retd.) of Killick Industries, elder daughter Smt. Usha Cheema, wife of Lt. Gen. N.S. Cheema, youngest daughter Smt. Ashavati Deshpande wife of Prof. S.A. Deshpande, grandchildren and great grandchildren and a host of relatives, friends and admirers in the forest fraternity to mourn his loss.

May his soul rest in eternal peace and his work continue to inspire the present generation.

- Y.G. Jadhav

(II)

Sridhar Sadashiv Buit

(28.5.1918 - 9.6.1996)

The sad news of the demise of Sridhar Sadashiv Buit, on 9th June 1996, at Pune after a brief illness, will fill many a heart with grief. He was 78. In his death, the country has lost a Forester of eminence, erudition and wide experience.

After a distinguished academic record at the Nagpur University, he chose Forestry as his professional career. Acquitting himself creditably, in the Superior Forest Service Course, at the Indian Forest College, Dehra Dun, in 1942, he commenced his Forestry career as Assistant Conservator of Forests in the erstwhile Madhya Pradesh. In recognition of his merit, he was assigned the charge of important forest circles, namely, Amravati and Chandrapur, known for their valuable teak forests, for the promotion of which he made notable contribution.

On linguistic reorganisation of the States, in 1960, he was allocated to the then bi-lingual Bombay State and later, on its bifurcation, he continued in Maharashtra, serving that State with distinction and competence, being at the helm of affairs as Chief Conservator of Forests, for a record term, of nearly a decade and a half. Holding the reins of this high office, at a climacteric phase of events, he steered the Department with admirable *savoir-faire*, leaving a stamp of his administrative genius and professional acumen. He drew up, a well-conceived and comprehensive Perspective Plan, for the all-round development of forests in Maharashtra, which was well-acclaimed.

He was a path-finder, with an innovative outlook and seldom, took a wrong turn, whenever he opened a new vista. The Forest Development Corporation, was a new concept in the mid-1960s, aimed at enhancing forest productivity and utilisation, at a faster pace, with greater autonomy and flexibility in management, in keeping with sound principles. He gave this concept, a flying start in Maharashtra, in 1969-70 and placed the Corporation on an even keel, under his able stewardship. Other aspects of development, such as : Forest Research, and Education, as also Wildlife Conservation & Management, acquired a new perspective and dimension, through his foresight, initiative and dynamism.

Contd...

To whatever he did, he brought a sense of dedicated duty and commitment. In whatever he undertook, he left the mark of his pre-eminence, quiet determination and efficiency. Something of the scholar's love for learning, shone in his attention, to the minutiae on any subject and his record of work, bore eloquent testimony, to his talents and ability. He wielded a facile pen, with a fine command, over the English language, carrying with ease, his erudition and scholarship. It was a treat, to read his reports and treatises, couched in chaste English, with a delightful turn of phrase, embellished by his pearly hand. His farewell dispatch, to his confreres, on the eve of his laying down office, was a gem, not only for its content and fine sentiment also, even for the felicity of expression. He had a flair, for Marathi literature too, which drew him close, to some of the well-known litterateurs, in that language.

At the various Seminars and Conferences, on diverse themes, on forestry and wildlife, in which he took part, he brought to bear, his wide knowledge and expertise and stood out, for the lucid exposition of his views.

As a person, he was endowed with rare charm and courtliness. Those who had the privilege, to work with him, will cherish for long, fond memories, of his innate grace, dignity and warmth. He was magnanimous, fair and just, to all, for which, he was respected and admired. He could upbraid and encourage, redress and appreciate, listen and temporise. These were the fine lineaments, of his head and heart, which endeared him, to one and all.

As hosts, both he and his wife, were gracious and generous, with the largesse of their heart, which won for them, a wide circle of friends. Even a junior probationer, was welcome to the warmth of their home.

Let not, his shining example and the fruit of his meritorious work, vanish with him but endure, for the edification and good of all.

May this be our prayer, in the words of a great writer, for eternal bliss, for the soul of the dear departed.

> "May the Lord, who supported him, all the day long, till the shades lengthened and the evening came and the busy life was hushed, and the fever of life, was over and his work done, in His mercy, grant him, peace at last, in the Great Beyond".

May the Lord grant solace to his bereaved widow and children and to his other near and dear ones, to whom, we offer our deepest sympathies.

- L.H.A. Rego

REVIEW

India's *Eucalyptus* Craze by N.C. Saxena, Published by Sage Publications Ltd., New Delhi. Price Rs. 275/-

The author starts with a statement "Trees have been an important part of the farm economy but goes on to quote reports that people were not interested in planting trees till about 1970 when farm forestry was launched. In subsequent chapter he discusses the different culture regarding agriculture between Western and Eastern U.P. His quotation "the Western U.P. culture encompassed respect for manual labour, industriousness, thrift and frugality, economic rationality and curtailment of ritualism. The East U.P. culture in contrast encompassed aversion to normal labour and industry, leisure preference, conspicuous consumption, excessive ritualism, traditionalism and indifference to economic enterprise". He maintains the same theme regarding the eastern part of the State. *Eucalyptus* planting has been equated with adoption of improved seeds of agricultural cover (MVs). Technical information regarding *Eucalyptus* have been superficially discussed in chapter 3. Chapter 4 is irrelevant to the title or theme of the book. Chapter 5 describes the methodology of field work, which is the basic requirement for a paper for a university degree but should have no place in a general book. Chapter 6 gives details of the six sample villages two each in Districts Allahabad, Muzaffarnagar and Nainital and admits that these villages do not capture the diversity of 90,000 villages in U.P. However, the title of the book indicates as if the study projects the situation of the entire country. Chapter 7 discusses the financial analysis of planting *Eucalyptus* though the title of the chapter refers to boundary plantations only. The quoted studies are location specific and the treatment does not enlighten the reader. The next chapter discusses the *Eucalyptus* markets in Western U.P. from 1983-84 to 1989-90. The economics of *Eucalyptus* planting has been compared with that of Poplars. Authors ignorance about trees is brought out by one sentence on page 195 "Better quality of seeds, extension and proper spacing ensured that most poplar trees grew to timber dimensions in about six to eight year's time suitable for sawing". Poplars are not multiplied through seed but by cuttings of selected clones. The Poplar logs are mostly peeled and not sawn. The last chapter gives a summary of the eight chapters. The title of the book is not relevant to the subjects actually dealt with in the book. The author has not even made a good case to justify why he equates *Eucalyptus* with God and where has it failed. The three paper mills in U.P. and Haryana are running largely on the supply of *Eucalyptus* wood produced on farmlands. The fall in prices of *Eucalyptus* is blamed largely to Government policies and market mechanism. The slackening in demand of *Eucalyptus* seedling is primarily because of availability of coppiced wood and wider spacings now being adopted by farmers.

- A.N.C.

From the Indian Forester - One Hundred Years Ago

THE
INDIAN FORESTER

JULY 1896 (pp. 264-266)

TURPENTINES OF *PINUS KHASYA* AND *PINUS MERKUSII*.

The crude turpentine from *Pinus khasya*, which was a grey thick, pasty mass, containing a quantity of small pieces of wood, furnished by distillation with steam about 13/100 of its weight of oil; while the product from *Pinus merkusii*, which was more fluid and clearer in appearance than the other, yielded nearly 19/100 of oil by corresponding treatment.

On a former occasion Professor Armstrong obtained from a sample of *Pinus khasya* 17 per cent. of oil, and he believes, therefore, that the particular sample now operated upon was collected under less favourable conditions, and that some of the oil had been lost by evaporation before the supply reached him.

The original turpentine and the distilled oil in each case have a very slight but agreeable odour, less pronounced in character than that of French turpentine, but distinctly characteristic. In this respect the oils from the two turpentines were very similar. Professor Armstrong has satisfied himself of the identity of the oil from *Pinus khasya* with that which he examined several years ago, and which is referred to in pages 20 and 21 of Hand-book No. 7.

Considerable difficulties attend the determination of the precise chemical composition of oils of this class, and methods with this object in view are, at the present time, in course of elaboration. Such experiments as Professor Armstrong has been able to make, have satisfied him that the oil of *Pinus khasya* is strictly comparable with French oil of turpentine. This conclusion corresponds with that which he arrived at several years ago, as stated in the Hand-book. In this respect the oil from *Pinus merkusii* closely resembles that of *Pinus khasya*.

Both oils distil within a very narrow range of temperature near to 155°C., as does the furnished oil of turpentine; but the oil from *Pinus khasya* appears to contain a somewhat larger proportion than the others of a constituent of higher boiling point.

The two oils are very nearly alike in relative density, *viz.*

	P. khasya	*P. merkusii.*
At 20°C	.8627	.8610

They both turn the ray of polarised light to the right, the so-called specific rotatory power being

P. khasya	*P. merkusii.*
36" .28	31" .45

A similar result was furnished by the oil from the sample of *Pinus khasya* formerly examined. The rotatory power of French turpentine is practically always about 36.

The difference between the oils from the two Burmese turpentines is not of a kind to be of any practical importance. They are essentially similar, the slight difference between them being due to the presence in one or other of a small quantity of some substance in addition to the chief constituent. Practically they correspond exactly in properties to French oil of turpentine. Professor Armstrong is disposed to think that the oil of *Pinus merkusii* may be more uniform than that from the other turpentine. He proposes to continue his experiments with these products for the purpose of endeavouring to determine their precise composition. Meanwhile, he states that both oils are of the highest quality, and that, in his opinion, they will be found to serve every purpose for which oil of turpentine (French or American) is used. They compare favourably even with the French oil, which is the highest quality in the market.

The resin or colophony which is left after distilling off the oil from the two samples is of good quality, and would be available for all purposes for which ordinary resin is used.

There appears to be no reason why India should not obtain whatever turpentine is required in the country from native sources. Professor Armstrong hopes, later on, to furnish a more detailed report in regard to the composition of the oils obtained from these two turpentines.

- F.A. Abel

FORTHCOMING FORESTRY/ENVIRONMENT PROGRAMMES (1996-97)

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Contact : E-mail: Sam. Kunkle @ fao. org.

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Contact : Kate Harris, Course Coordinator, Oxford Forestry Institute, University of Oxford, South Parks Road, Oxford OXI 3 RB U.K.

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Contact : J. Box, USDA Agricultural Research Service, Conservation Research Center, 1429 Experimentation Station Rd., Wathinsville, GA, USA,

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Workshop on Biodiversity Information, London, U.K.
Contact : Dr. Colin Ogbourne, Informationo Services, CAB International, Wallingford, Oxon, OX10 8DE, U.K.

29 July - 1 August, 1996
Planning and implementing Forest Operations for Sustainable Development, Marquette, MI, U.S.A.
Contact : Esko Mikkonen, Univ. of Helsinki, Deptt. of forest resources management, Unionikatu 40B, Pin 00170 Helsinki, Finland.

5-8- August, 1996
Diversity and adaptation in forest ecosystems in a Changing World, Vancouver, BC, Canada.
Contact : Francis C. Yeh, Dept. of Renewable Resources, University of Alberta, Canada, T6G2H1.

6-10 August, 1996
Physiological aspects of Xylogenesis in Conifers, Krasnoyarks, Russia.
Contact : V.N. Sukachv, Institute of Forests, Krasnoyarsk, 660036 Russia,

13-17 August, 1996
Quality wood drying through process modelling and novel technologies. Quebec City, Canada.
Contact : Dr. Alain Cloutier, Forintek Canada, Corp: 19 rue Franquet, Sainte-Foy (Quebec),Canada GI P4R4.

18-23 August
Population Dynamics, Impacts, and integrated management of forest defoliating insects, Banska, Stiavnica, Slovak Republic.
Contact : Dr. Mike McManus, Northeastern Center for Forest Health Research, 51 Mill Pond Rd, Hamden, CT 06514, USA.

24-August- 1 Sept,1996
Connection between Silviculture and Wood quality through modelling approaches and simulation. Softwares. Kruger National Park, South Africa.
Contact : Gerard Nepveu, INRA, Equipe de Recherches sur la qualite des Bois, Centre de Recherches - INRA de Nancy, 54280 Champenoux, France.

13-22 October, 1997
XI World Forestry Congress, Antalya (Turkey).
Contact : The Secretary General, XI World Forestry Congress, Dept. of Foreign Relations - Ministry of Forestry, Ataturk Bulvari - 153, Ankara (Turkey).

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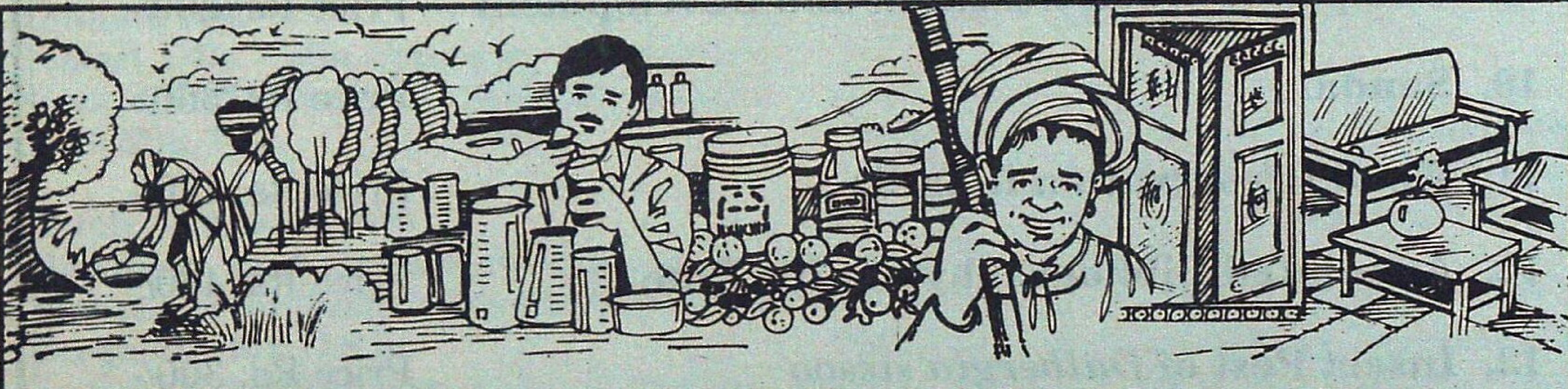

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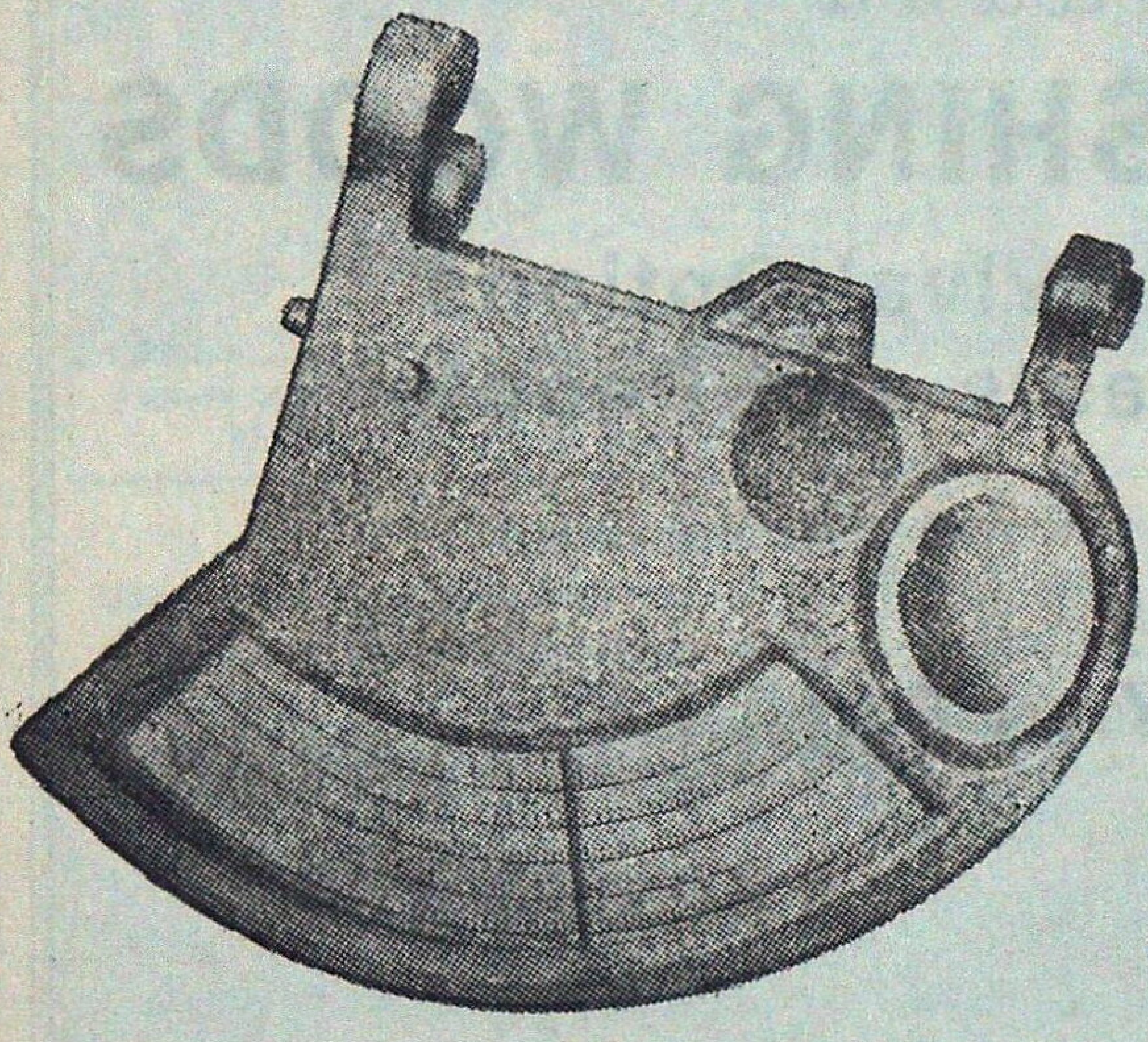

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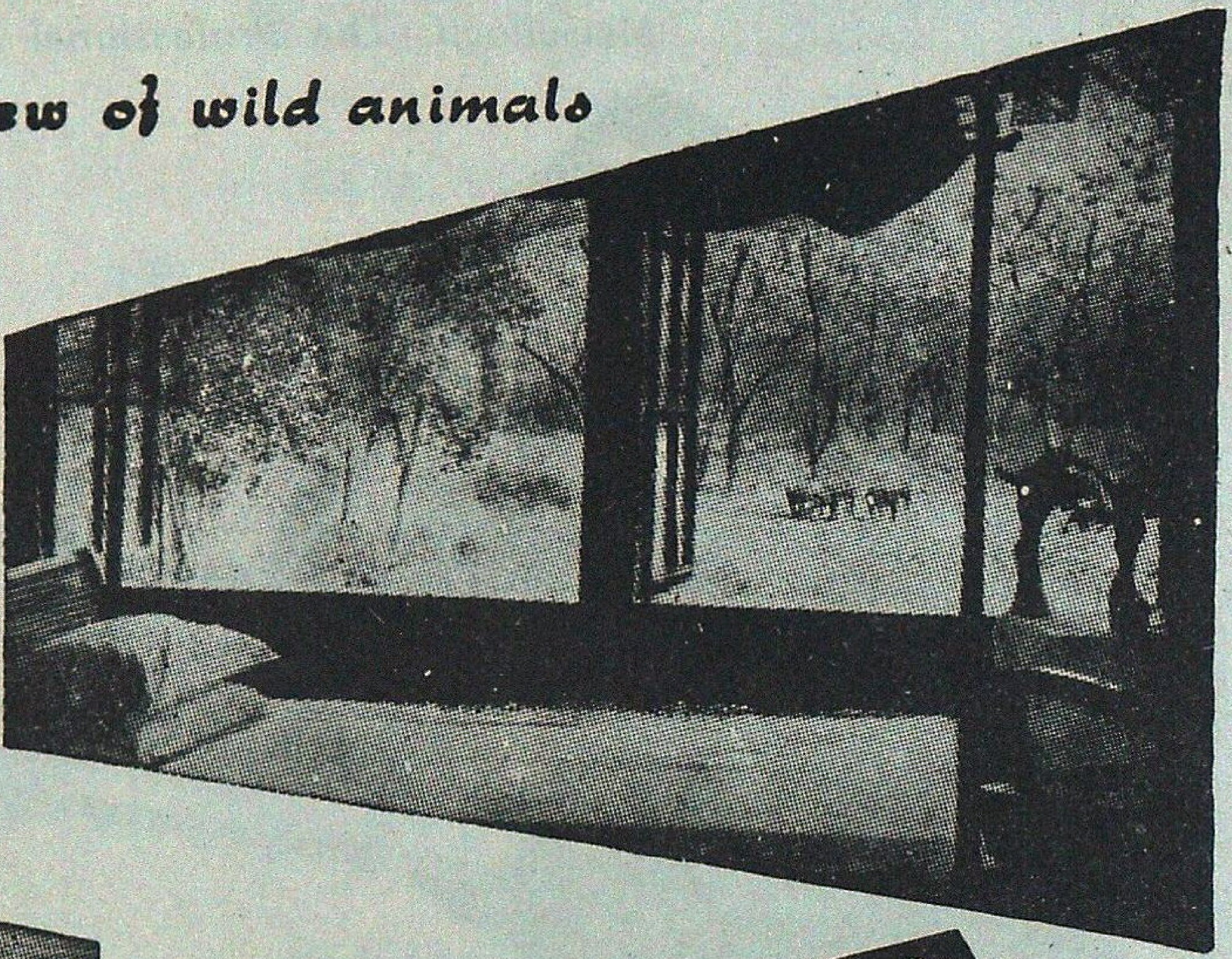

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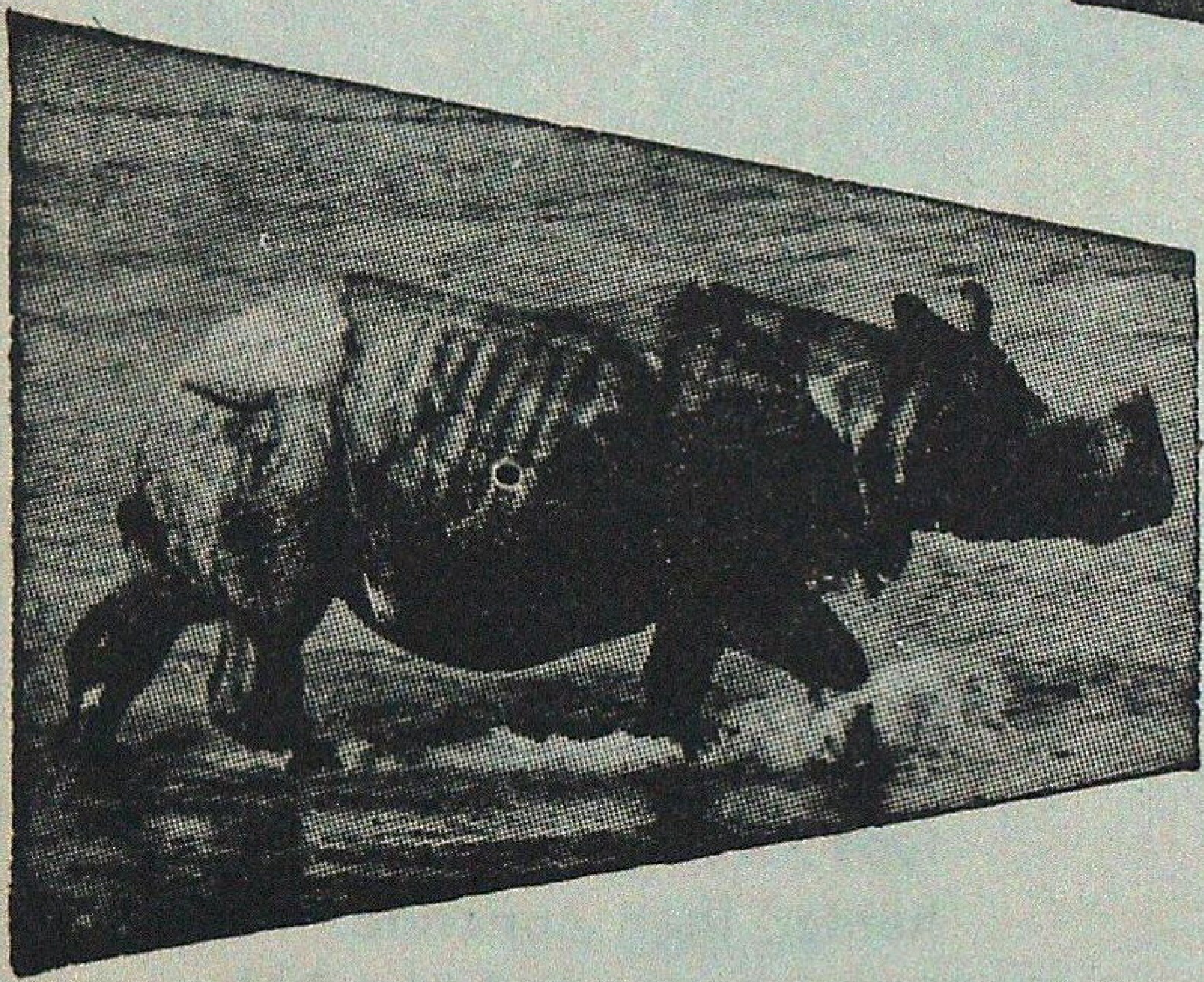

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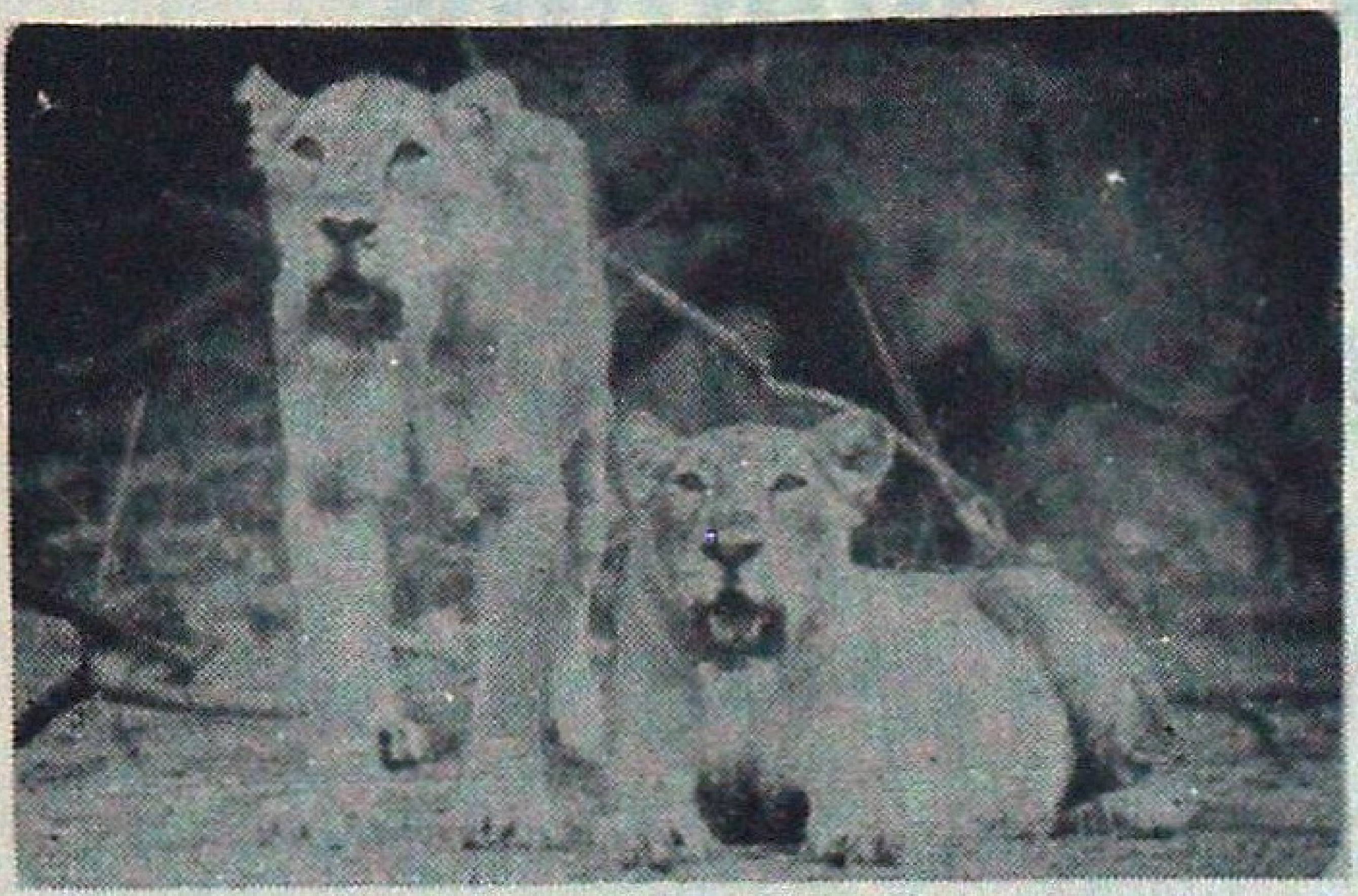

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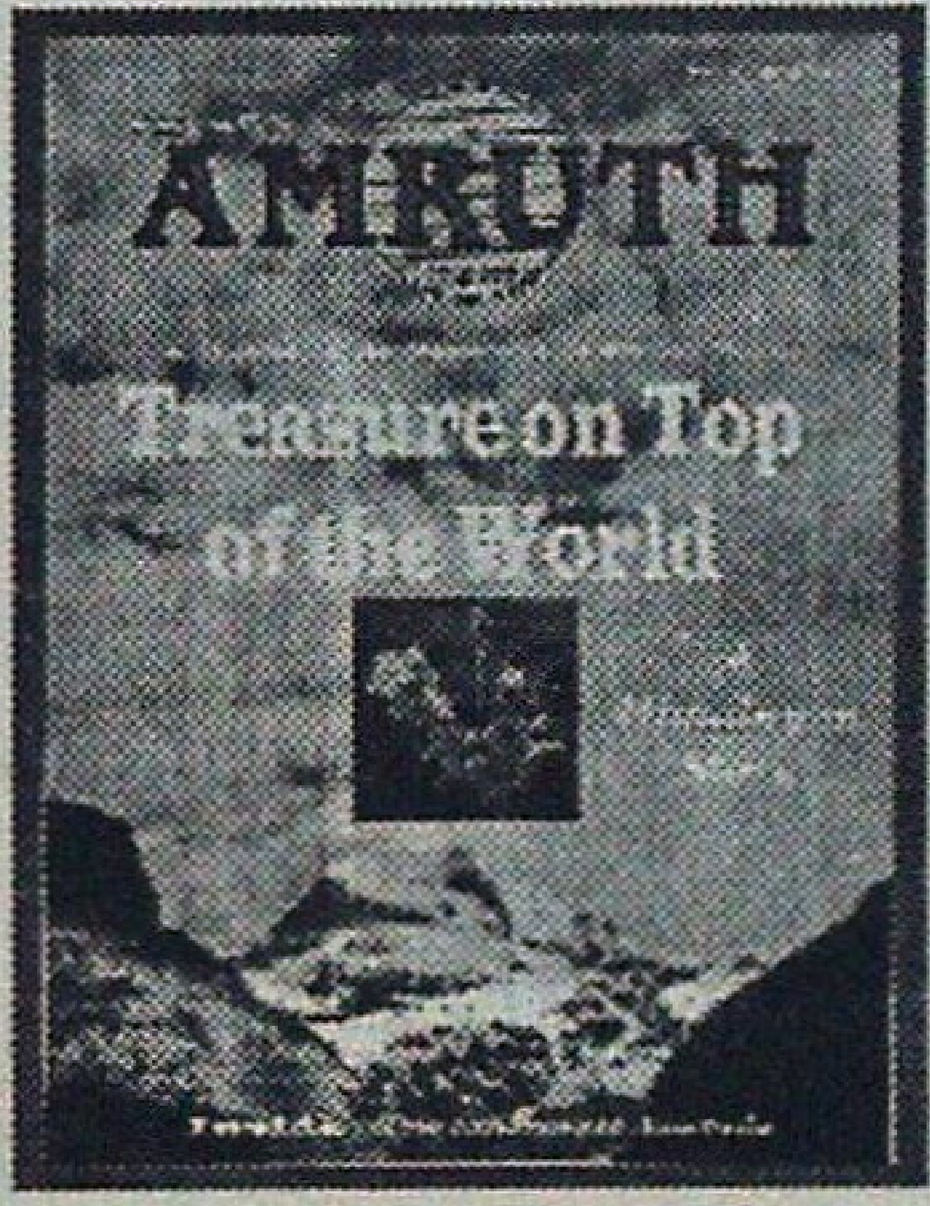

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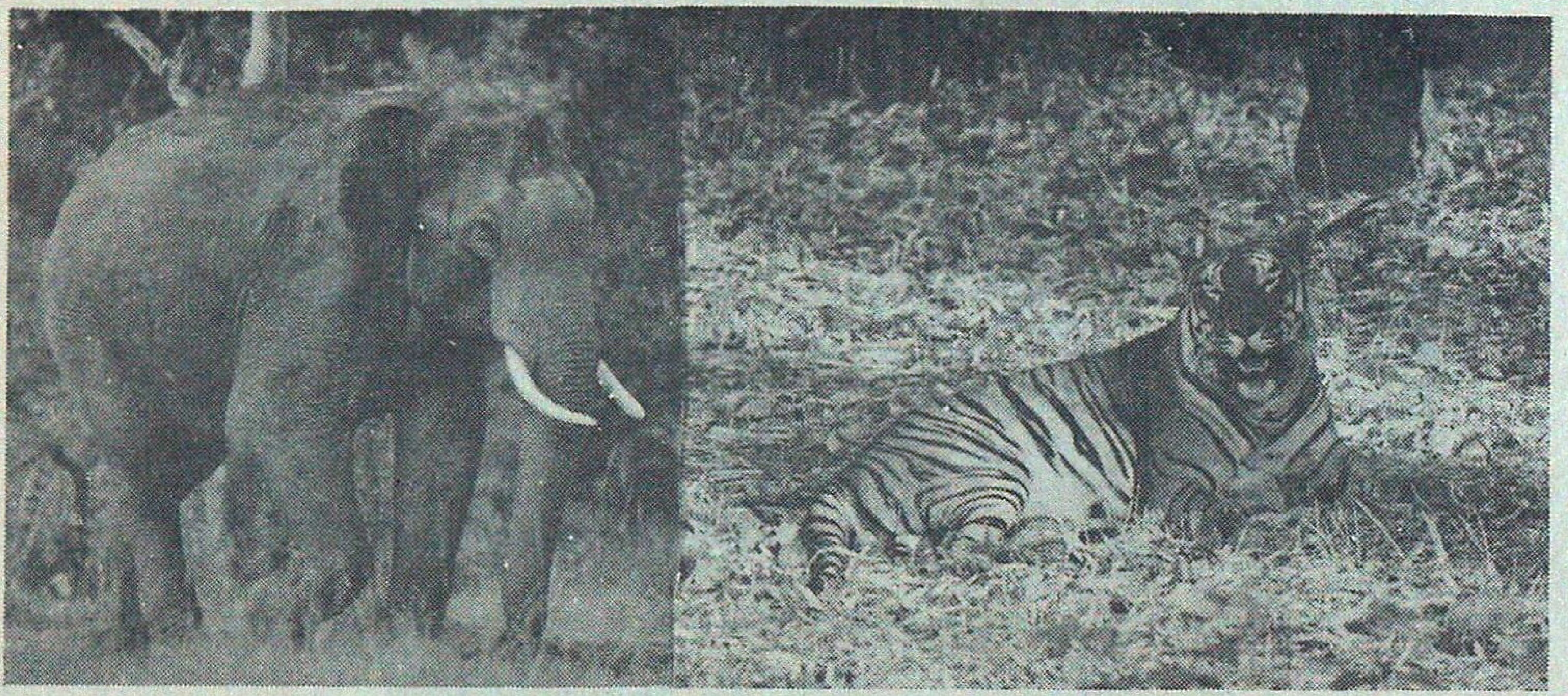

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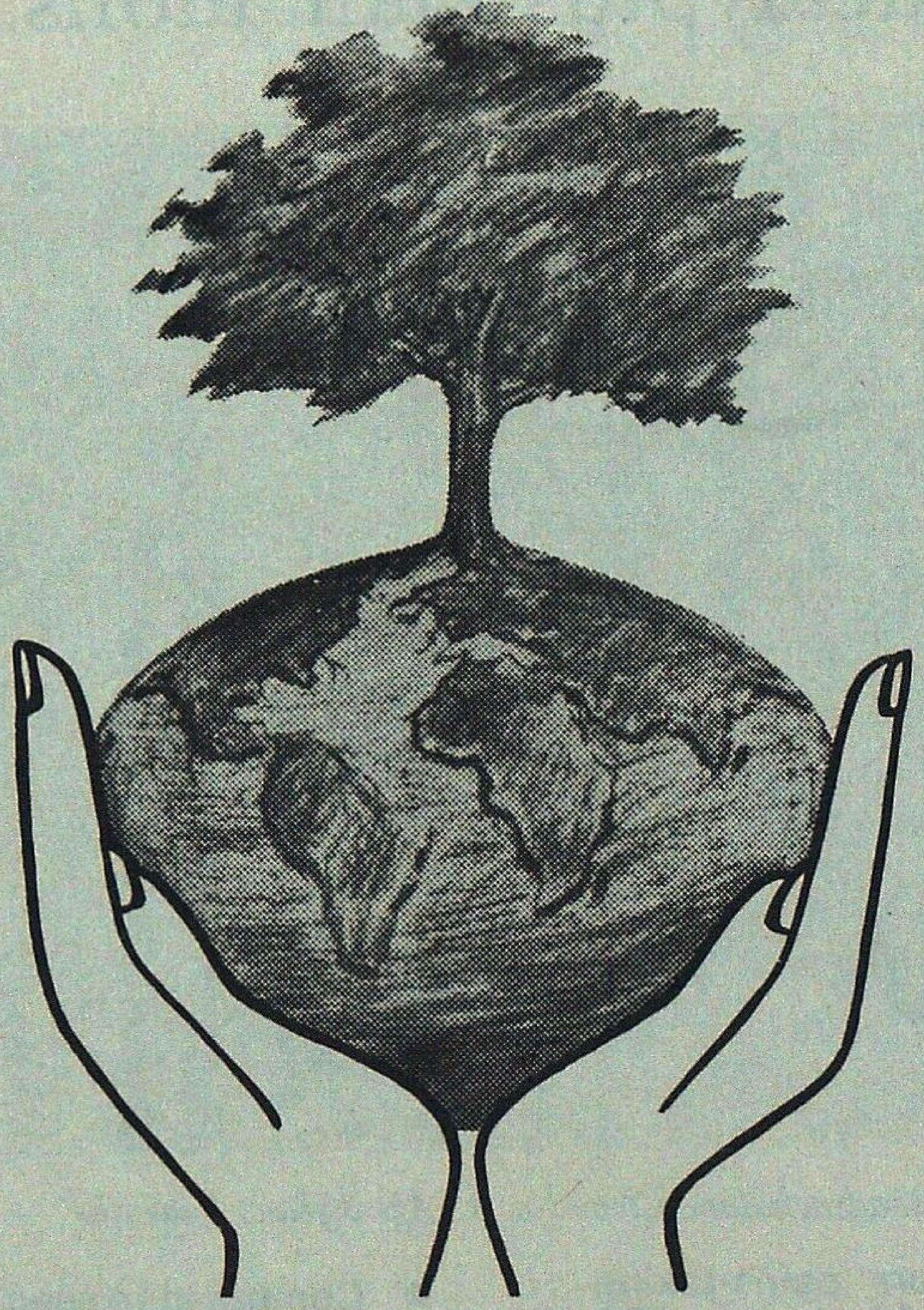

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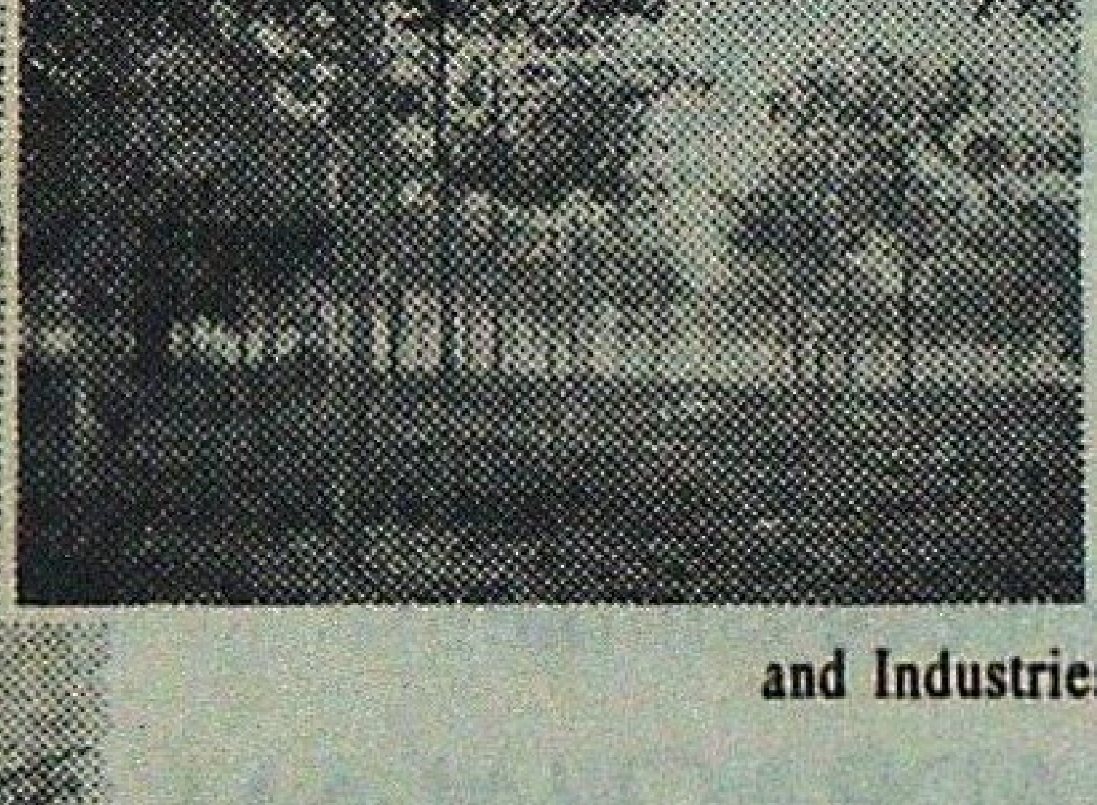

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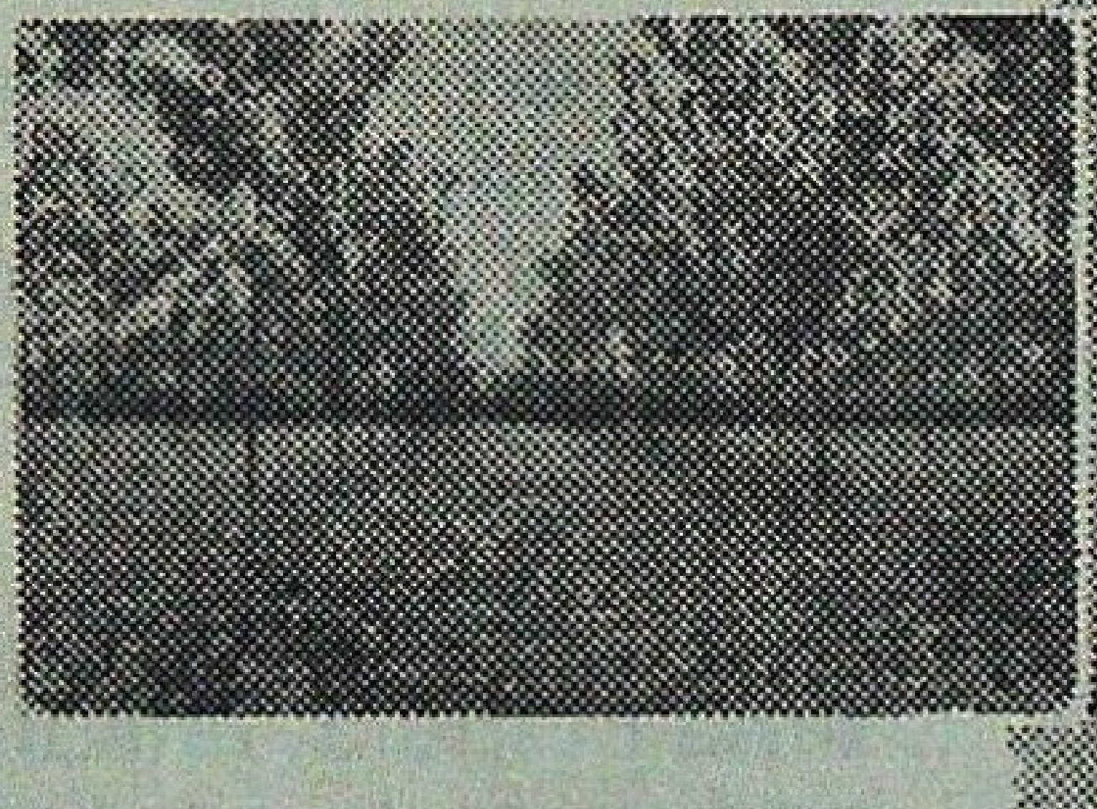

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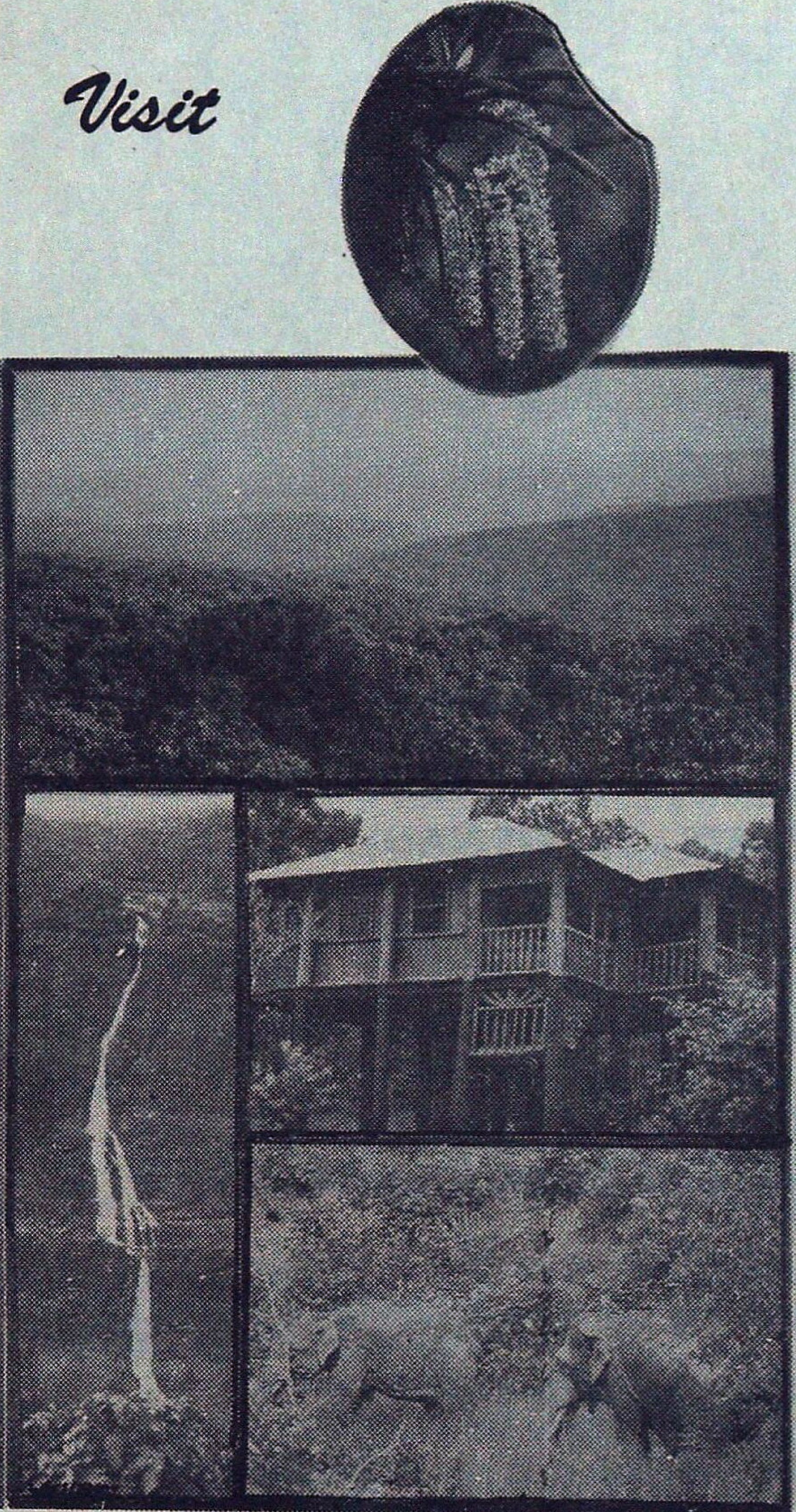

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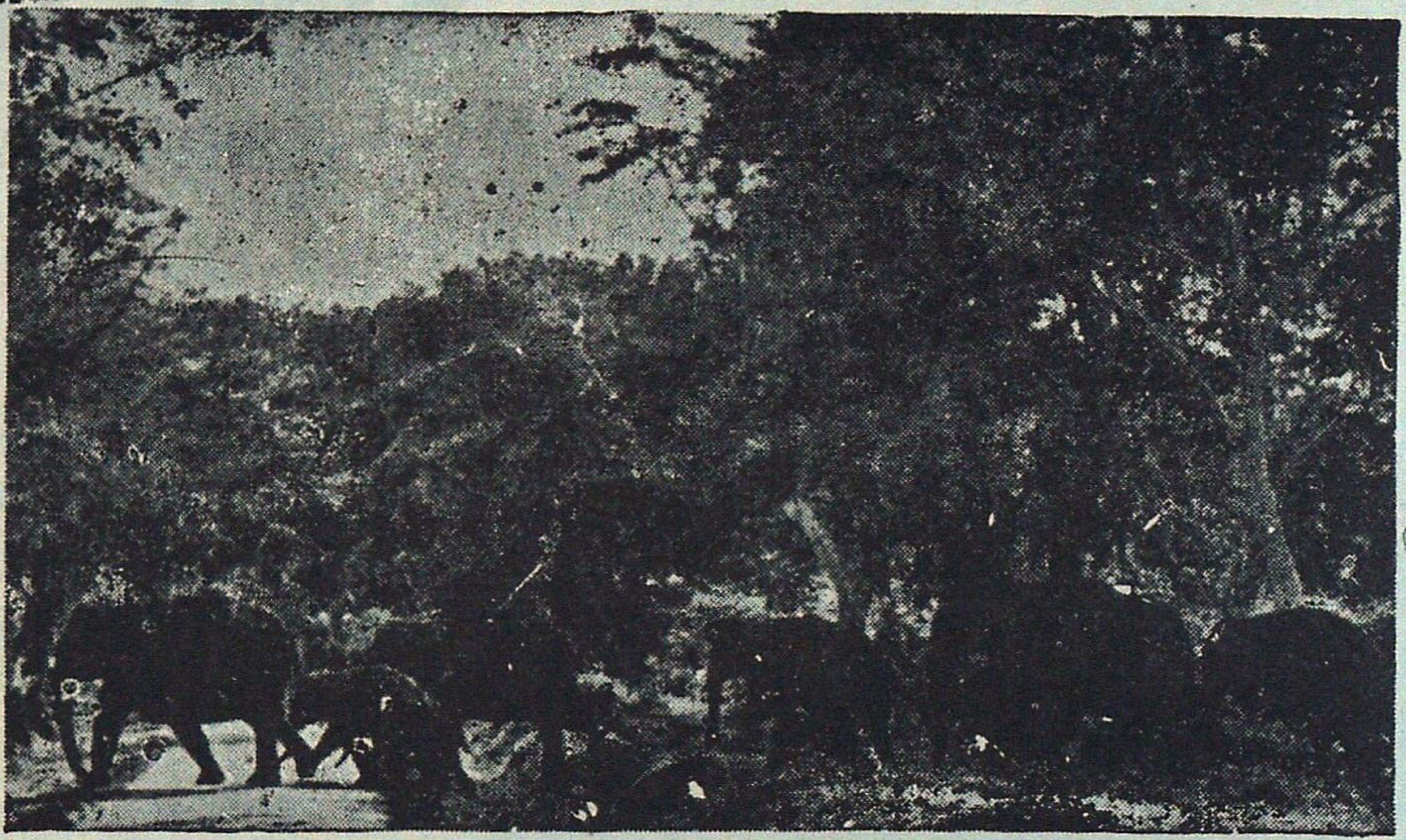

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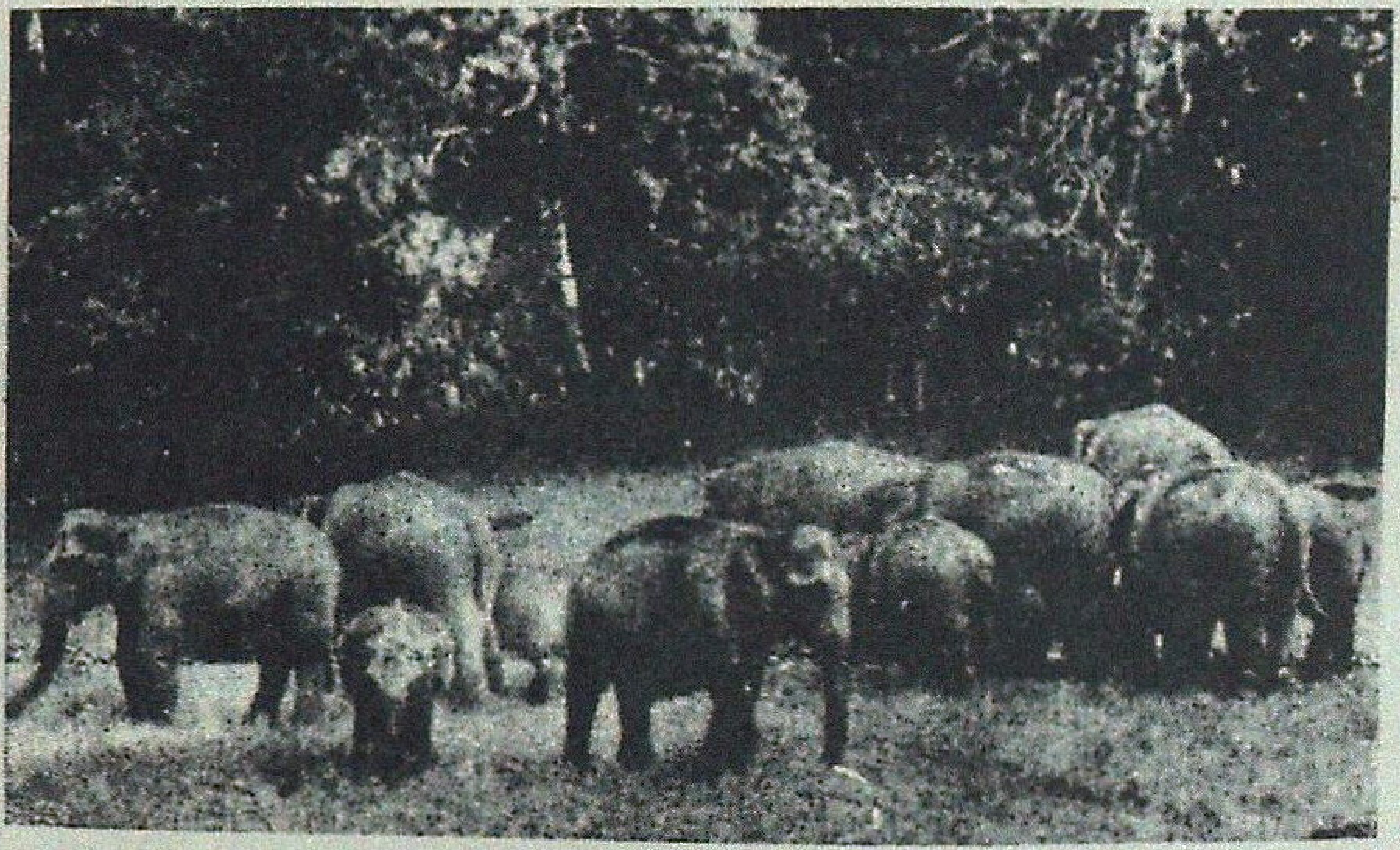

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